CONODONTS, GONIATITES AND THE BIOSTRATIGRAPHY OF THE EARLIER CARBONIFEROUS FROM THE CANTABRIAN MOUNTAINS, SPAIN

by A. C. HIGGINS *and* C. H. T. WAGNER-GENTIS

ABSTRACT. Six conodont zones, including one new one, the *Paragnathodus multinodosus* Zone, are represented in the Lower Carboniferous of the Cantabrian Mountains. The absence of conodont zones known to occur in north-west Europe points to four major stratigraphic gaps in the Spanish sequence, three in the Tournaisian and one in the Visean. High conodont abundances, indicating a low rate of sedimentation in the Tournaisian rocks, and the numerous gaps in the stratigraphic record point to a slow initial Carboniferous transgression. The patchy distribution of earliest Tournaisian sediments contrasts with the widespread distribution of the latest (*anchoralis* Zone) Tournaisian sediments when the transgression reached its culmination. Lower conodont abundances and thicker successions coincide with a more complete Visean/early Namurian sequence in which only one major break is detectable. A goniatite fauna from the lower Visean is described including one new genus, *Pseudogirtyoceras* and two new species *P. villabellacoi* and *Winchelloceras palentinus*. This fauna confirms the early Visean age of the *typicus* Zone. One new species of conodont, *Scaliognathus angustilateralis* sp. nov., is also named.

THE Dinantian and early Namurian sedimentary sequence in the Cantabrian Mountains of north-west Spain consists of less than 50 m of condensed deposits formed on the Cantabrian Block. This was a stable platform uplifted during the late Famennian and the recipient of renewed sedimentation from latest Famennian onwards. The age and nature of these sediments is not always the same all over the area and this is true particularly of the deposits formed during the latest Famennian and Tournaisian. Several formations are involved (compare Wagner, Winkler Prins, and Riding 1971). The earliest deposits belong to the Ermita Formation (Grès de l'Ermitage of Comte 1959) which was laid down after the Famennian uplift and which appears to have a diachronous base, older at the flanks of the uplift and younger in its central part. A calcareous sandstone lithology is the most common for the Ermita Formation but limestone has been recorded in the top part. Samples in the highest Ermita Formation yielded conodonts attributed to the *costatus* Zone (Higgins, Wagner-Gentis, and Wagner 1964), but a few localities have now shown the presence of a *Protognathodus* fauna of earliest Carboniferous age. The Ermita Formation thus appears to span the latest Famennian and the earliest Tournaisian.

In the south-eastern part of the Cantabrian Mountains, corresponding to the northern part of the province of Palencia, there is an area which shows many resemblances to the western Pyrenees and which is characterized by a nodular limestone, the Vidrieros Formation of Van Veen (1965), spanning the Famennian–Tournaisian boundary (Van Adrichem Boogaert 1967). This region does not show the effects of Famennian uplift and contains a different development of Devonian strata, i.e. the Palentine facies of Brouwer (1964). It occupies an area between two major faults, viz. the Ruesga Fault in the south and the southern boundary fault of the Picos de Europa to the north. Appreciable tectonic shortening is a feature of both faults and the abrupt contacts between areas of different facies development is apparently due to extreme telescoping as a result of the tightening of the arcuate fold belt in north-west Spain (R. H. Wagner, pers. comm.).

The Ruesga Fault is apparently continued westwards by the León Fault of Marcos (1967)

(originally described as the León Line by De Sitter 1962). Although this important fracture zone has been widely credited as a syn-sedimentary control, it seems to be due to post-sedimentary tectonics with a telescoping effect which gradually diminishes westwards (R. H. Wagner, pers. comm.). The sediments investigated for the present paper were all laid down south of the León–Ruesga tectonic fault line (text-fig. 1) even though some of the localities are presently north of this fault.
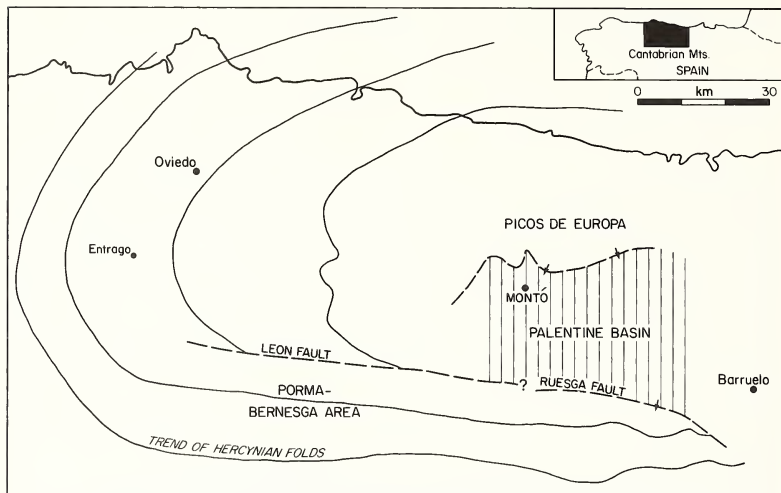
TEXT-FIG. 1. Structural palaeogeographic areas, Palaeozoic, Cantabrian Mountains.

In this area the Ermita Formation is generally present. It is followed by either the Vegamián Formation of black shales or the Baleas Formation of crinoidal limestone. These two formations (Wagner *et al.* 1971) seem to be mutually exclusive. Since they both seem to correspond to the same time interval within the Tournaisian (*cooperi-communis* Zone of the present paper) it may be that the Baleas Limestone was formed on ridges in the basin which received the Vegamián Shales (compare Higgins *et al.* 1964). The Baleas Formation, described by Wagner *et al.* (1971) is only a few metres thick. The Vegamián Formation (Comte 1959; Wagner *et al.* 1971) is generally less than 10 m thick. It is characterized by phosphatic and chert nodules and black shales which are often cherty. Its macrofauna includes the goniatite *Muensteroceras arkansanum* Gordon, as recorded by Wagner-Gentis (in Wagner *et al.* 1971). This species was described originally from the late Kinderhookian of Arkansas, U.S.A.

The most widespread formation in the Carboniferous of north-west Spain is the succeeding Genicera Formation of Wagner *et al.* (1971) which is the 'Marbre Griotte' of Barrois (1882) (also called Villabellaco Formation—Wagner and Wagner-Gentis 1963—and Alba Formation—Van Ginkel 1965). It is characterized by nodular and wavy-bedded limestones and up to 25 m thick. The basal unit (Gorgera Member of Wagner *et al.* 1971) is marly and usually a vivid red colour, although a slightly reddish-grey colour has also been found. Over a large area of northern León, including the Genicera type section, an interval of red shales and cherts (Lavandera Member) separates the basal,

marly unit of nodular limestones from the main part of generally wavy-bedded to nodular limestones (Canalón Member of Wagner *et al.* 1971). The chert unit is absent in the southernmost exposures of northern León and in the Revilla Nappe structure of northern Palencia. Conodont work reported in the present paper shows that the chert unit corresponds to a sizable time gap which is equally apparent where the cherts are absent. The basal unit, which is only a few metres thick, has yielded goniatites of the late *Pericyclus* (II β/γ) Zone corresponding to late Tournaisian. Its conodont fauna corresponds to the *anchoralis* Zone. The Gorgera Member may be occasionally absent and although the rare occurrences where this seems to be the case ought to be checked for thrusting (shearing in the

Age	SSW of Genicera (León)		Olleros de Alba (León)
	Formation	Member	Formation
Namurian A/B	Barcaliente		Barcaliente
			Olleros
	Genicera	Canalón	Olaja Beds
Visean		Lavandera	Genicera
		Gorgera	
Tournaisian	Vegamián		Vegamián
Famennian	Ermita		Ermita

TABLE 1. Formations in the Porma–Bernesga area, based on Wagner *et al.* (1971).

flanks of isoclinal synclines is of common occurrence in the Cantabrian Mountains), it appears likely that the base of the Genicera Formation may not always be of exactly the same age.

The top of the formation reaches into the lower Namurian (E_2b Zone) and is undoubtedly diachronous. Wagner *et al.* (1971) described the Olaja Beds, a condensed mudstone sequence of only a few metres, as the lateral equivalent of the highest part of the Canalón Member. The lower Namurian Olaja Beds occur only in the southernmost exposures of the Cantabrian Mountains in northern León, where they form the base of a thick terrigenous sequence with turbidites (Olleros Formation of Wagner *et al.* 1971). In the more northerly exposures, the more complete Canalón Member is followed with gradual transition by the Barcaliente Limestone Formation. The latter was formed on a carbonate platform (the same Cantabrian Block as accumulated the Genicera Limestone and Chert Formation) which was sufficiently shallow to give rise to evaporitic sediments. The presence of a turbidite basin to the south indicates the diminished area of the Cantabrian Block in mid-Namurian times, whilst the terrigenous facies of the Olaja Beds provides an early indication of the northwards withdrawal of the southern margin of the block in early Namurian times.
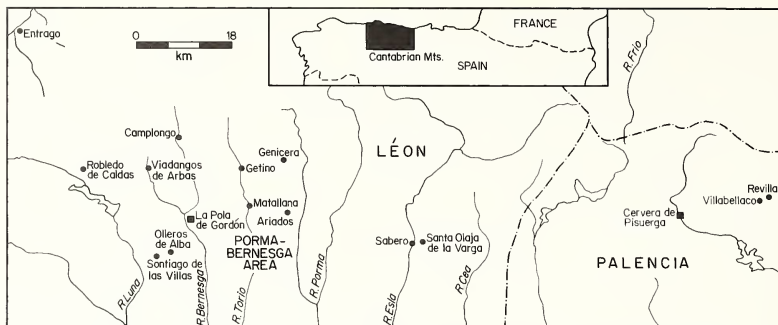
TEXT-FIG. 2. Location of the sampled sections in the southern part of the Cantabrian Mountains.

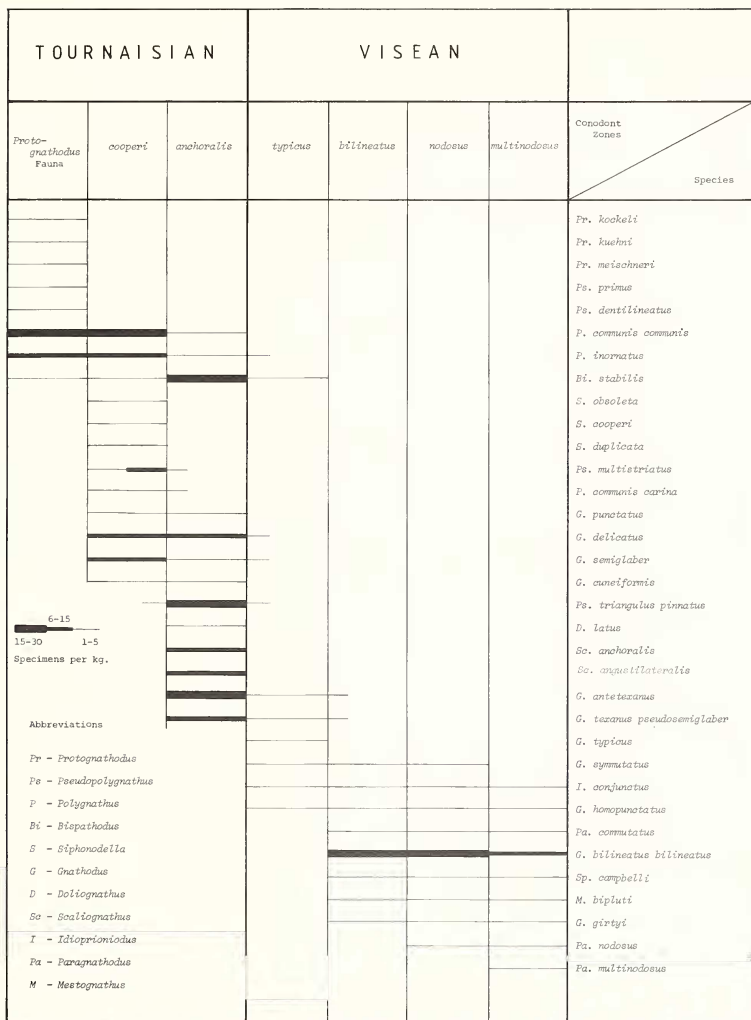## CONODONT ZONES AND LOWER VISEAN GONIATITE OCCURRENCE

Six conodont zones and a *Protognathodus* fauna are represented in the sequence but the boundaries of the fauna and the lower three zones are non-sequences and the sequence is probably incomplete. Five of these concurrent range zones were defined by Higgins (1974) but are here modified and one zone is new.

Protognathodus fauna. The base of the Ermita Formation is a transgressive horizon of late Devonian age, belonging to the *costatus* Zone of Ziegler (1962). In only two of the sections, the Aviados and the Villabellaco sections in the Porma–Bernesga area, does the base of the Carboniferous rest on pre-*costatus* rocks. On the other hand, only at Santiago de las Villas and Olleros de Alba is there a transition between the Devonian and Carboniferous where a thin limestone at the top of the Ermita Formation yields a conodont fauna belonging to the *Protognathodus* fauna. This fauna includes *Polygnathus communis communis* Branson and Mehl, *Polygnathus inornatus* sensu Branson and Mehl, *Protognathodus kockeli* (Bischoff), *Protognathodus meischneri* Ziegler, *Protognathodus kuehni* Ziegler and Leuteritz, and one specimen doubtfully referred to *Pseudopolygnathus dentilineatus*. This fauna was referred to the *kockeli-dentilineatus* Zone by Higgins *et al.* (1964) as was a similar fauna described by Adrichem Boogaert (1967) from the Triollo area. The presence of *Protognathodus kuehni* suggests that this fauna belongs to the younger *Protognathodus* fauna of Ziegler (1969). The presence of a newly discovered siphonodellid in this fauna also clearly indicates closer affinity with the Upper rather than the Lower *Protognathodus* fauna. This siphonodellid was referred by Higgins (1974) to *Siphonodella sulcata* (Huddle) but it is poorly preserved and of very doubtful determination. The assignment of these samples to the Upper *Protognathodus* fauna places them in the Carboniferous rather than at the top of the Devonian (Sandberg, Ziegler, Leuteritz, and Brill 1978).

Siphonodella cooperi–polygnathus communis Zone. This zone, defined by Higgins (1974), is widespread in the Porma–Bernesga area where it occurs in the Baleas and Vegámian Formations. Key species in the rich and abundant faunas include *Siphonodella obsoleta* Hass, *S. duplicata* Branson and Mehl morphotype 2, and *S. cooperi* Hass morphotype 2 of Sandberg *et al.* (1978). These range from the Upper *Duplicata* Zone to the Upper *Crenulata* Zone according to Sandberg *et al.* (1978). However, *Gnathodus delicatus* Branson and Mehl, *G. punctatus* (Cooper), and *G. semiglaber* Bischoff, which are also present in the zone, overlap the range of species of *Siphonodella* in the Belgian Tournaisian (Groessens 1977*b*) in late Tn$_2$. Also present in the zone is *Polygnathus communis carina* Hass which first appears in Tn$_3$ in the Belgian sequence. A late Tn$_2$/early Tn$_3$ age indicates the span of the *cooperi-communis* Zone. This age probably indicates at least partial equivalence to the German *crenulata* Zone (see text-fig. 7).

Anchoralis Zone. The *anchoralis* Zone is easily recognized and is a widespread zone in the Cantabrian Mountains. *Scaliognathus anchoralis* Branson and Mehl, *Doliognathus latus* Branson and Mehl, *Pseudopolygnathus triangulus pinnatus*, *Gnathodus texanus* (Roundy) *pseudosemiglaber* Thompson, and *G. delicatus* are

TOURNAISIAN			VISEAN					
Proto-gnathodus Fauna	cooperi	anchoralis	typicus	bilineatus	nodosus	multinodosus	Conodont Zones / Species	

Pr. kockeli

Pr. kuehni

Pr. meischneri

Ps. primus

Ps. dentilineatus

P. communis communis

P. inornatus

Bi. stabilis

S. obsoleta

S. cooperi

S. duplicata

Ps. multistriatus

P. communis carina

G. punctatus

G. delicatus

G. semiglaber

G. cuneiformis

Ps. triangulus pinnatus

D. latus

Sc. anchoralis

Sc. angustilateralis

G. antetexanus

G. texanus pseudosemiglaber

G. typicus

G. symmutatus

I. conjunctus

G. homopunctatus

Pa. commutatus

G. bilineatus bilineatus

Sp. campbelli

M. bipluti

G. girtyi

Pa. nodosus

Pa. multinodosus

6-15

15-30   1-5

Specimens per kg.

Abbreviations

Pr - Protognathodus

Ps - Pseudopolygnathus

P - Polygnathus

Bi - Bispathodus

S - Siphonodella

G - Gnathodus

D - Doliognathus

Sc - Scaliognathus

I - Idioprioniodus

Pa - Paragnathodus

M - Mestognathus

TEXT-FIG. 3. Ranges of the stratigraphically important conodont species in the Cantabrian Mountains.

Locality	sample	Ps primus	Pa dentilineatus	P. communis communis	P. inornatus	Bi stabilis	S. absoleta	S. cooperi	S. duplicata	Ps multistriatus	P. communis carina	G. punctatus	G. delicatus	G. semiglaber	G. cuneiformis	Ps triangulus primulus	D. latus	Sc anchoralis	Sc angustidorsalis	P. bischoffi	G. anteexanus	G. texanus pseudosemiglaber	G. typicus	G. symmutatus	Pa communis	G. bilineatus	Sp campbelli	Pa nodosus	Pa mulrindosus	M. bipluri	total per kilo
Aviadas	1171IV														6					1		2									9
	III			30											4					2	2	6	6								50
	II	1	15	12			4							20	5																57
	1497			12	10																										22
	1496	1		20	10			2																							33
	1494	2		27	15	1			3																						48
Matallana	1060P																									10		7			17
	O																									22		16	2		40
	M																						10		20			7	6		43
	L																						4		22			14			40
	K																								21			12			33
	J																						3		61			6			70
	I																								60	4		10			74
	H																						2		25						27
	G																						1		40						41
	F																						6		50	5					61
	D													5	60	25															90
	C														5	4															9
	B															1	3	13	20												37
	A															1	39	3													43
Baleas Quarry	1263					2	5							5		1		1		3	20	10									47
	1264					3	23												60	62	100	50	30								328
	1516		1	1			36							10				62	3	7	120										240
	1519					7	1													20	80	6									114
	1521	8	12	60	30					15	10			6		1	12	6	48	3											211
	1524		3							1																					4
Pola de Gardán	1210E																										6	1			7
	D																								1	2		2			5
	C																								1	12		30			43
	B																									2					2
	A																									2					2
	1207B													6	8					3		4									21
	A		1	46														40		7		2									96
	1206			17							1																				18
	3085		29	10		3	6	3	50		1	28	2	40																	172
	3084		3	6				6	1		4	13																			43
Beberina	1209B													20	33								10								63
	A															15							15	30	40						100
	1364			12									1	3	40	10		40	22						6						134
	1200C						23								41	3							24	50							141
Olleros de Alba	OLXVIII																										2			1	3
	XVII																										4				4
	XVI																										10				10
	XV																										4				4
	XIV																									1	9	8	2		20
	XIII																										5	6			11
	XII																									1	4	1			6
	IX																										2	3			5
	VIII																								1						1
	VII																							3							3
	VI														4					1			1	3							9
	V						1												1	3			3	2							10
	IV																						3	9							12
	III					2	2										1						4	1	1						11
	II								18													2	6	1							27
			2				26													66	2	6								102
	15		8			1															12	7									28
	1348		1				23		16																						40

TABLE 2. Distribution and abundance of conodonts from the Cantabrian Mountains.

among the key indices in a rich and varied fauna. *D. latus* is used as a basal subzonal index in the Missouri (Thompson and Fellows 1970) and Belgian (Groessens 1977b) sections. In the Porma–Bernesga area, *D. latus* is present throughout the zone and in most samples of this age, which implies that the upper part of the zone is missing in the southern part of the Cantabrian Mountains, and that the zone is of early Tn_{3c} age.

Gnathodus typicus Zone. This zone was defined by Marks and Wensink from the Pyrenees (1970). The characteristic species *G. typicus* Cooper, *G. antetexanus*, and *G. texanus pseudosemiglaber* mark the beginning of

species / sample	P. communis communis	P. inornatus	Bi. stabilis	S. subsolus	G. delicatus	G. semiglaber	Ps. triangulus pinnatus	D. latus	Sc. anchoralis	Sc. anpularianensis	P. bischoffi	G. antetexanus	G. texanus pseudosemiglaber	G. bilineatus	G. symmutatus	G. homopunctatus	Pa. communis	Sp. campbelli	G. girty	Pa. nodosus	Pa. multinodosus	total per kilo
Rabledo de Caldas 1197B																	2	3	4			19
1196	1																3	2				6
1194					5													4				9
1193	1	4		1	2							1	1	3	5							8
Viadangos de Arbos 1358														10	20							30
1357					5	30	10															45
Camplanga 3520													2					1	2			5
N												20	2	15	3							40
M												14		7	4							25
L												25	4		10	2						41
K														1								1
J														2								2
H												50			5	1						56
H												4	40		4	12						60
E												45			2							47
F												6	30	5	2	20						63
O												2	10	6	6							24
C											2	40	2									44
C											2	20	5	2	1							40
B											1	25	10									36
A											6	30	20	2								58
3077	12										1	8	3	15								39
Getina 1069T														1								1
S												2			2							4
R												1			1							4
P											26	40			8	1						75
O												2			2							4
N												1										1
M											6	7			4	1						18
L												4			1							5
K												2										2
J											6	6			2	3						27
I											5	25			10	6						43
H											10	50	6		10	6						82
G											1	25										26
F	4												14	5	8							32
E											2	10										12
D											7	25	2	10								44
C											6	20										26
B											7	21										28
A											17	10	60	6								93
Venta de Getino 1072N												1										1
M											1	12										13
L												2										2
K												11										11
J												103			6	2						111
I											1	1			1							3
H											2				4							6
G											6	10	19			3						38
F											1	1	10									12
E											1											1
D												4										4
C											1	13										14
B											1	6										7
1340	5					5					19	2	14	7		10						57
Genicera 1169B					1								11				1					13
1166C			1								1	20	5									27
966B			23		4	10	10		2	2	14	14										158
1338	1		2																			4

species / sample	Pr. kockeli	Pr. meischneri	P. communis communis	P. inornatus	Bi. stabilis	Ps. multistriatus	G. delicatus	G. semiglaber	Ps. triangulus pinnatus	D. latus	Sc. anchoralis	G. antetexanus	G. texanus semiglaber	G. typicus	G. homopunctatus	Pa. communis	G. bilineatus	Sp. campbelli	G. girty	Pa. nodosus	Pa. multinodosus	M. bipli	total per kilo
Santiago de las Villas 1120															1								1
1119															1	1							2
1118															4								4
1117															1								1
1116															1								1
1115														1	7		2						10
1114			1										1	2	1	1							6
1113														1									1
1112									4														4
1111												2											2
1110														1									1
1314			1					2	1	2	28	10	2										46
1311								36	20	1	6												63
1310	3	8	1	42	1	3																	58
Entraga 1149T															1	1							2
N															1								1
M								3	14														14
L								1	12														14
K							1	2	78	28					9	9							127
J							2	3	4						1	1							5
H								2	2						2	2							6
G									1						7								8
F									12	44					9								165
O							14	4	2	15					3								38
O									10	12					1								23
C									4	25													29
B					10	3		1				1			2								17
A						5																	5
Villabellaco 2916														1	2					4			72
2915									1	2	6	49	4	10									72
2913												2		2									4
2912												1		1									3
2911												2		1									6
2910												2	22			8	4	6					43
2909												2		2									3
2908												17	6			8							31
2906											9	10	25										44
2905											7	21	42	32									102
2904												4	4										8
2903											14	18	21								3		48
2902								3				14	36										53
2908												1	21										24
138C												10	2										24
2899			9		2	1	6	6	16	6		2	5										53
Revilla 134XI												10	3	53	17		25	25					133
X													31										31
IX												3	9	51	2								65
VIII												1	28		5								34
VII												5	55		13								73
VI												5	3	25		3	10						46
V												9	23	53	5								180
IV												7	30										57
III														1			12	7					20
II											4		8										12
I											4	3	1	17									134
Sta Olajad Vargo 372							6				1		8		1								16
S.E. of Genicera 1103III													6										6
IV												90	4			10							104
V													20	10									30

TABLE 3. Distribution and abundance of conodonts from the Cantabrian Mountains.

the dominance of species of *Gnathodus* which characterizes much of the Visean and early Namurian. *G. homopunctatus* Bischoff appears at the base of the zone and this occurrence together with the other species would suggest an equivalence of this zone to the *G. homopunctatus* Subzone of V_{1a} age in Belgium (Groessens 1977b).

The goniatites from the basal marly unit (*typicus* Zone) of the Villabellaco Limestone in northern Palencia have been found in the following sequence:

138 D, 5·0 m above the base   *Pseudogirtyoceras villabellacoi* sp. nov.
                                   Merocanites marshallensis (Winchell)
                                     Merocanites subhenslowi Wagner-Gentis
                                     Ammonellipsites kayseri (Schmidt)

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Gnathodus typicus Zone. This zone was defined by Marks and Wensink from the Pyrenees (1970). The characteristic species *G. typicus* Cooper, *G. antetexanus*, and *G. texanus pseudosemiglaber* mark the beginning of

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138 p, 5·0 m above the base

Pseudoglyphioceras villabellacoa sp. nov.
Merocanites marshallensis (Winchell)
Merocanites sublaevidowi Wagner-Gentis
Ammonellipsites kayseri (Schmidt)

138 C, 2–3 m above the base   *Merocanites marshallensis* (Winchell)
                                     Merocanites subhenslowi Wagner-Gentis
                                     Ammonellipsites kayseri (Schmidt)
                                     Nautellipsites hispanicus (Foord and Crick)

1–1·2 m above the base   *Merocanites marshallensis* (Winchell)
                                     Muensteroceras cf. *crassum* Foord

138 b, 0·5–0·6 m above the base   *Winchelloceras palentinus* sp. nov.

136 B, east of locality 138, at   *Muensteroceras parallelum* (Hall)
     the same level as 138 C

Merocanites marshallensis and *Winchelloceras* are known from the Marshall Sandstone in Michigan, which is considered to belong to the Osagean (Manger 1979, pp. 214, 215). Popov (1968) recorded *Winchelloceras* from the *Fascipericyclus* 3 Zone (Lower Visean) of the Tien Shan in Central Asia and (1975) from the c_1v_1 unit in the Urals.

Ammonellipsites kayseri has been described from Liebstein (Erdbach and Breitscheid section), West Germany in the Peγ Zone, in Aragón (Spain), Schmidt (1931) mentioned it with a Lower Visean fauna and in south-west England it occurs at Tawstock and Coddon Hill (Prentice and Thomas 1960, p. 6).

Muensteroceras parallelum was described from the Rockford Limestone of Indiana. A conodont fauna below the ammonoid layer in the type locality belongs to the Osagean (Rexroad and Scott 1964) and Manger (1979, p. 213) attributes the goniatite bed also to the Osagean. The species is also known from the S_1 unit of the Hassi Sguilma Stage of Pareyn (1961, p. 50 and table IV) which contains a basal Visean fauna. Librovitch (1927, p. 42) mentioned this species from the Tien Shan, where it occurs with a fauna of the middle and upper '*Pericyclus* Stufe' (Schmidt 1925).
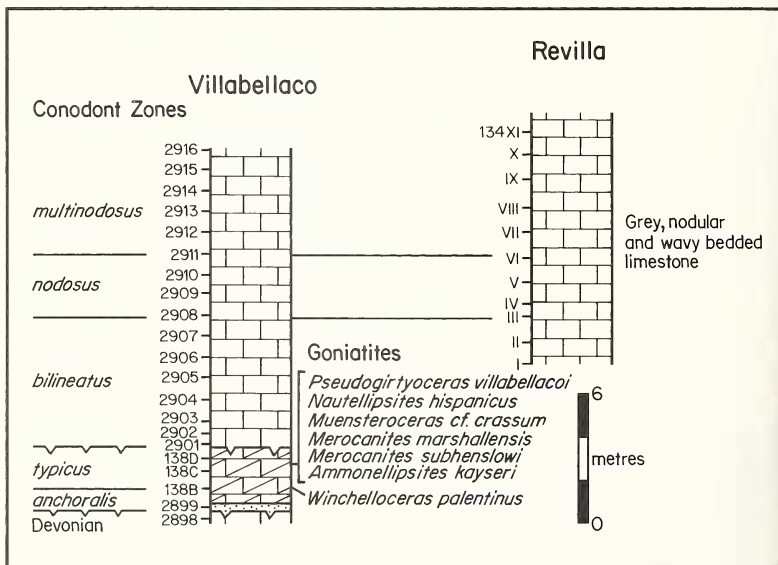
TEXT-FIG. 4. Conodont zones and lower Visean goniatite occurrence in the Villabellaco area, Revilla Nappe.

Muensteroceras cf. *crassum* is known from the Lower Carboniferous Limestone of Ballinacarriga, Co. Limerick, Eire.

Merocanites subhenslowi and *Nautillepsites hispanicus* have previously been described from Olleros de Alba (León) and Villabellaco (Palencia) (Higgins *et al.* 1964; Wagner-Gentis 1960). In both papers it was suggested that they occurred in an equivalent to the lower B-zone, but this is now seen to be incorrect. An earlier horizon is involved. The lower part of the Villabellaco Limestone yielded conodonts of the *typicus* Zone (Higgins, this paper) which corresponds to V_{1a} of the Belgian sequence. An early Visean age is also indicated by the majority of the goniatite species found.

The goniatite fauna from the lower part of the Villabellaco Limestone has *Muensteroceras parallelum* in common with the Rockford Limestone of Indiana, and *Merocanites marshallensis* and *Winchelloceras* (a different but comparable species, *Winchelloceras allei*) with the Marshall Formation of Michigan. The latter has been assigned an early Visean age by Miller and Garner (1955, pp. 118–119) (see also Brenckle, Lane, and Collinson 1974) but a late Tournaisian age by Manger (1979, p. 221, fig. 3). The lower part of the Villabellaco Limestone containing the goniatites comparable to those of the Marshall Formation, has also yielded conodonts of the *typicus* Zone which belongs to V_{1a} of the Belgian sequence. It thus appears that the Marshall Formation, may be lower Visean rather than upper Tournaisian. On the other hand, *Kazakhstania*, another element of the Marshall Fauna, is regarded as a late Tournaisian index (Librovitch 1940, pp. 324–325; Manger 1971). This goniatite does not occur in the Villabellaco Limestone.

Gnathodus bilineatus Zone. The marked reduction of the *texanus* group and its disappearance a little way into the zone marks the beginning of the *Gnathodus bilineatus* Zone. This change coincides with the appearance of the important *G. bilineatus* (Roundy) and *Paragnathodus commutatus* (Branson and Mehl). This abrupt change is due to the absence of several faunas, notably the late appearance of *P. commutatus* which appears before *G. bilineatus* in northern Europe, and the absence of the *G. texanus* fauna which is important in Missouri (Thompson and Fellows 1970).

Paragnathodus nodosus Zone. The increase in the complexity of *P. commutatus* by the addition of platform nodes marks the appearance of *P. nodosus* (Bischoff). This widespread species appears in the zone of *Neoglyphioceras spirale*, Go β in Germany (Meischner 1970) and in V_3b in Belgium (Groessens 1977b). *G. bilineatus* is still a very important zonal constituent.

Paragnathodus multinodosus Zone. The increasing complexity of platform ornamentation marks the appearance of *P. multinodosus* (Wirth). Again *G. bilineatus* is an important element of the fauna. Budinger and Kullmann (1964) related the appearance of *P. multinodosus* to the *granosus* Zone (Go γ). The consistent later appearance of *P. multinodosus* relative to *P. nodosus*, often only 1 m higher, is only detected in closely sampled sections. The *P. multinodosus* Zone continues into the overlying Namurian where in the absence of the later form of *G. bilineatus*, *G. bilineatus bollandensis* and the rarity of *G. girtyi* Hass it has not proved possible to subdivide the early Namurian.

Consideration of the Faunas. The faunas are dominated by platformed conodonts with wide basal cavities and flaring platforms typified by species of *Gnathodus* and *Paragnathodus*. In the Visean these are characteristic of deep-water cephalopod limestones in many parts of the world and the deep-water nature of the Visean griotte limestones and the presence of goniatites confirms this as a general observation. Nevertheless, both in the Tournaisian and the Visean there are peculiarities in the faunas which are worthy of note.

The Tournaisian faunas are of two types: one, occurring in the crystalline limestone of the Baleas Formation and the basal unit of the Genicera Formation, is dominated by gnathodids whereas the other, occurring in the fine grained limestone of the Ermita Formation and in the conglomerates and shales of the Vegamián Formation, is dominated by siphonodellids and polygnathids. Meischner (1970) suggested that the gnathodid faunas of the German *anchoralis* Zone were characteristic of schwellen environments whereas the polygnathids dominate in the basin environments. Matthews, Sadler, and Sellwood (1972) suggested that the contrast is between faunas with large basal cavities and flaring platforms, the gnathodids, and those with small basal cavities, the polygnathids. The distribution of the Baleas Formation in the Porma–Bernesga region is in the form of an east–west trending area within the Vegamián shale outcrop and it was suggested by Higgins *et al.* (1964) that it was formed on a ridge, in a deeper-water sea. The conodont faunas would confirm this view, because the Vegamián faunas, although few, are dominated by polygnathid conodonts. Whether the
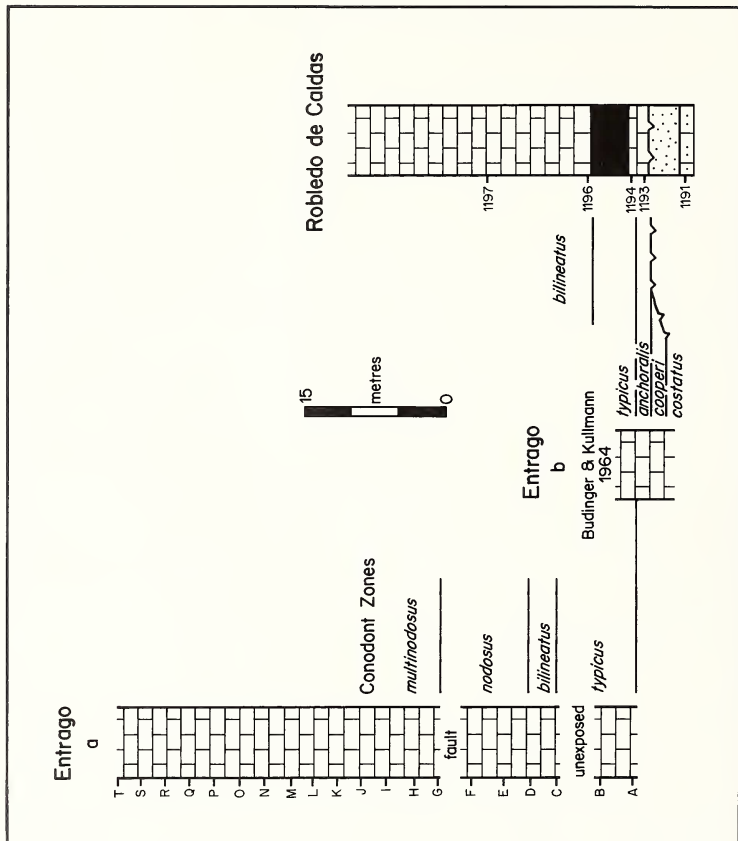
TEXT-FIG. 5. Conodont zones in the sections at Entrago and Robledo de Caldas.
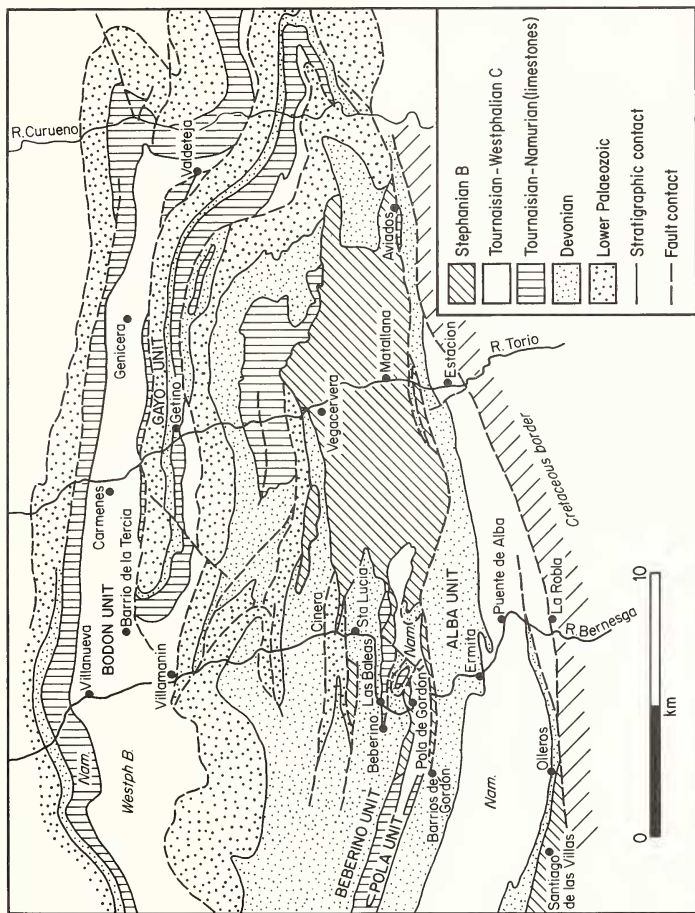
TEXT-FIG. 6. Generalized geological map of part of northern León after Wagner et al. (1971) with structural units after de Sitter (1962).

crystalline limestone faunas of the Baleas were formed in the same depth of water as the griotte limestone is unknown but it seems likely in view of the similarity of conodont type.

The other anomaly occurs in the Visean where the rarity of *G. girtyi* contrasts with its abundance in the basin limestones and shales of northern Europe. This species is occasionally found in the *G. bilineatus* Zone but principally occurs in the *P. nodosus* Zone. In the Pyrenees (Marks and Wensink 1970) it appears to occur only in the *P. nodosus* Zone. There is no record of *G. girtyi* in the Namurian of Spain. Similarly, the absence of *G. bilineatus bollandensis*, the high abundance of *Spathognathodus campbelli* Rexroad, and the almost total restriction of *P. multinodosus* to the Cantabrian Mountains and the Pyrenees, point to the partial geographic isolation of this area during the early Namurian (E_1, E_2).

IMPLICATIONS OF THE CONODONT DATINGS FOR THE HISTORY OF THE AREA

Comparison of the conodont sequence with more complete ones in Belgium, Germany, and Great Britain indicates the presence of considerable breaks in the Lower Carboniferous succession in the Cantabrian Mountains. However, there is little evidence of extensive erosion and the lack of faunal reworking and the high faunal abundance implies slow but continuous deposition separated by periods of non-deposition. The sequence of events is as follows:

			Average number of specimens/Kg
NAMURIAN (E_1, E_2)			
———	*multinodosus* Zone	⎫	⎧ —
	nodosus Zone	⎬ Continuous deposition	⎨ 39
	bilineatus Zone	⎭	⎩ 27
VISEAN		Widespread non-deposition	
	typicus Zone	Widespread deposition	19
———		Local non-deposition	
	anchoralis Zone	Major transgression	97
		Widespread non-deposition, some erosion. Continuation of swell topography during early part of the zone	
TOURNAISIAN	*cooperi-communis* Zone	Development of swells Widespread non-deposition	89
	Upper *Protognathodus* f.	Patchy distribution	
———		Erosion surface in most areas	
DEVONIAN	*costatus* Zone	Widespread transgression	

Late Devonian history. Adrichem Boogaert (1967) clearly demonstrated the transgressive nature of the late Devonian rocks which, in the form of the Ermita Formation, commonly rest unconformably on the underlying rocks.

Tournaisian history. There are undoubtedly sections in the Cantabrian Mountains which show a transition from the Devonian into the Lower Carboniferous. The sections at Santiago de las Villas and Olleros de Alba in the Porma–Bernesga area yield the earliest Carboniferous, Upper *Protognathodus*, fauna in a sequence which is uninterrupted from the Devonian. Unfortunately, the latest Devonian rocks do not yield conodont faunas. A transition probably also exists in the Vidrieros Formation in the northern part of the Palentine Basin (Adrichem Boogaert 1967) where the *costatus* Zone is followed by the *Protognathodus* fauna, but a full sequence of zones has not yet been demonstrated. Similarly, there may well be a transition in the Cándamo Formation in Loredo, but again a full sequence of zones has not been proved (Del Rio and Menéndez Alvarez 1978). These are

CANTABRIAN MOUNTAINS		BELGIUM (after Groessens 1975, Higgins & Bouckaert 1968)		GERMANY (after Meischner 1970, Conil & Paproth 1968)		SIPHONODELLA ZONATION (after Sandberg et al. 1978)
Pa. multinodosus	E_2	*G. bilineatus bollandensis*	E_2	*G. bilineatus schmidti*	E_2	
			E_1		E_1	
Pa. nodosus	v_{3c}	*Pa. nodosus*	v_{3c}	*Pa. nodosus*	Go_γ	
			$v_{3b\gamma}$		Go_β	
G. bilineatus bilineatus		*G. bilineatus bilineatus*	$v_{3b\alpha}$	*G. bilineatus bilineatus*	Go_α	
		Few conodonts	$v_2-v_{3\alpha}$	*anchoralis-bilineatus*		
G. typicus		*Pa. commutatus*	v_{1b}	interregnum.		
		G. homopunctatus	v_{1a}			
S. anchoralis		*S. anchoralis*		*S. anchoralis*	Pe	
		E. burlingtonensis				
		D. latus				
	M. beckmanni	*Do. bouckaerti*		?		
	S. anchoralis	*Sp. bultynoki*				
	P. communis carina	*Do. hassi*	Tn_3	*S. crenulata*		*isosticha–U. crenulata* / *L. crenulata*
S. cooperi–P. communis		*Siphonodella*	$Tn_{1b}–Tn_2$	*Si. triangulus triangulus*	Ga	*sandbergi*
				Si. triangulus inaequalis		*U. duplicata* / *L. duplicata*
				kockeli-dentilineatus		*sulcata*
U. Protognathodus fauna		*Protognathodus fauna*		*U. Protognathodus fauna*		*praesulcata*
costatus	Tn_{1a}			*L. Protognathodus fauna* *M. & U. costatus*	Wo	

TEXT-FIG. 7. Correlation of the conodont sequence in the Cantabrian Mountains with those of Belgium and Germany. The suggested faunal and stratigraphic breaks in the Spanish sequence are indicated by diagonal lines.

CANTABRIAN MOUNTAINS	BELGIUM (after Groessens 1975, Higgins & Bouckaert 1968)			GERMANY (after Meischner 1970, Conil & Paproth 1968)		SIPHONODELLA ZONATION (after Sandberg et al. 1978)
Pa. multinodosus	E_2	G. bilineatus bollandensis		E_2	G. bilineatus schmidti	
Pa. multinodosus	E_1	///////		E_1	Pa. nodosus	
	V_{3c}	Pa. nodosus		Go_γ	Pa. nodosus	
Pa. nodosus	$V_{3b\gamma}$	Pa. nodosus		Go_β		
G. bilineatus bilineatus	$V_{3b\alpha}$	G. bilineatus bilineatus		Go_α	G. bilineatus bilineatus	
(hatched)	$V_2-V_{3\alpha}$	Few conodonts			anchoralis-bilineatus	
G. typicus	V_{1b}	M. beckmanni	Pa. commutatus		interregnum.	
	V_{1a}	M. beckmanni	G. homopunctatus			
S. anchoralis (hatched)	Tn_3	S. anchoralis	S. anchoralis	Pe	S. anchoralis	
		S. anchoralis	E. burlingtanensis			
S. anchoralis		S. anchoralis	D. latus		?	
S. cooperi-P. communis		P. communis carina	Do. bouckaerti			
		P. communis carina	Sp. bultyncki			
		P. communis carina	Do. hossi		S. crenulata	isosticha-u. crenulata L. crenulata
	$Tn_{1b}-Tn_2$	Siphonodella		Ga	Si. triangulus triangulus	sandbergi
(hatched)		Siphonodella			Si. triangulus inaequalis	u. duplicata L. duplicata
					kockeli-dentilineatus	sulcata
u. Protagnathodus fauna					u. Protagnathodus fauna	
	Tn_{1a}	Protagnathodus fauna		Wo	L. Protagnathodus fauna M. & U. costatus	praesulcata
costatus	Tn_{1a}					

TEXT-FIG. 7. Correlation of the conodont sequence in the Cantabrian Mountains with those of Belgium and Germany. The suggested faunal and stratigraphic breaks in the Spanish sequence are indicated by diagonal lines.

the exceptions, however, for the Devonian–Carboniferous boundary is usually an erosion surface representing a regression of early Carboniferous age. In the Porma–Bernesga area the gap at the base of the Carboniferous increases in size in a northerly direction from Santiago de las Villas to Viadangos de Arbas where the Visean rests directly on the late Devonian (see text-fig. 8). This trend is also seen in the pre-Ermita unconformity in this area (Adrichem Boogaert 1967) where it was interpreted as part of a general trend of increasing hiatus in a northerly and easterly direction towards the 'Asturian Geanticline' which occupies the central part of the Cantabrians. The same trend towards this platform area is evident in the Lower Carboniferous, but is one of increasing disconformity rather than unconformity and is an expression of the Bretonic Movements.

These early Tournaisian (Tn_{1b}) deposits represent the termination of the late Devonian transgression and were followed by a long period of regression. Evidence of the upper part of the *sulcata* Zone and the following zones up to the upper part of the *sandbergi* Zone of Sandberg *et al.* (1978) is lacking. Comparison with Belgium (Groessens 1977b) reveals the absence of all but the highest part of the *Siphonodella* Zone or lower part of the *Polygnathus communis carina* Zone which implies a gap ranging from Tn_{1b} to Tn_{3a}. This regression is represented in all sections of the Porma–Bernesga area by an erosion surface. The subsequent transgression resulted in a different pattern of sedimentation due in part to the emergence of positive areas in a generally subsiding basin. Dominating the facies pattern is the Vegamián Formation, a thin sequence of black, often cherty, shales with thin conglomeratic and phosphatic nodule horizons. In the Porma–Bernesga area a conglomeratic sandstone at the base of the Vegamián Formation at Santiago de las Villas and Genicera yields a fauna of polygnathids, siphonodellids, and pseudopolygnathids belonging to the *cooperi-communis* Zone. The upper limit of the Formation is more difficult to define. The highest beds of the Genicera section yield *Pseudopolygnathus triangulus pinnata* Voges, which ranges through Tn_3 in Belgium and in other sections it is overlain by beds of *anchoralis* (Tn_{3c}) age. A pre-*anchoralis* age for the major part of the Vegamián seems likely, although an early *anchoralis* age for the highest part cannot be ruled out. To the east and north-east of the Porma–Bernesga area, the base of the Vegamián appears to be of *cooperi-communis* age (Adrichem Boogaert 1967) where the faunas were referred to the lower *anchoralis* zone. The upper *anchoralis* appears to be diachronous since Budinger and Kullmann (1964) recovered late Visean (GoIII α/β) goniatites from the highest part of the Formation, although Wagner *et al.* (1971) question the attribution of these faunas to the Vegamián Formation.

In the Porma–Bernesga area, along a zone extending from Aviados to Pola de Gordón, the Vegamián black shales are absent and their place is taken by the crystalline limestones of the Baleas Formation. This thin unit, 12 m thick, is rich in conodonts with an average of eighty-nine conodonts per kilogram, indicating slow sedimentation. The faunas are of the swell type and indicate the presence of a swell extending east–west through the Porma–Bernesga area, which is here named the Pola de Gordón Swell. In the area to the east, north of Sabero, a similar crystalline limestone again replaces the Vegamián Shales and is also of *cooperi-communis* age (Adrichem Boogaert 1967). It may represent the easterly continuation of the Pola de Gordón Swell. At Entrago, Budinger and Kullmann (1964) recorded from the lower part of the sequence a crystalline limestone of 'Baleas' type also yielding a mid-late Tournaisian conodont fauna. As in the area to the south, the Vegamián is absent and it seems probable that this marks the position of another swell. These swells are close to, and parallel with, the early Carboniferous coastline (see Adrichem Boogaert 1967) and represent crinoidal banks forming on ridges close to the shore-line.

The *anchoralis* Zone, although extremely thin (*c.* 2 m) is the most widespread horizon in the Tournaisian of the Cantabrian Mountains and represents a considerable extension of the sea. In the majority of sections the base of the zone is an erosion surface, but one section, at Genicera, exhibits a transition from the Vegamián Formation into the overlying Genicera Formation. The earliest deposits of the zone included the top 1 m of the Baleas Formation in the Pola de Gordón area where erosion surfaces at the base and top separate the unit from *cooperi-communis* Zone below and the later part of the *anchoralis* Zone above. The most widespread part of the zone occurs at the base of the Genicera Formation where it occupies the basal metre of the red and grey nodular limestones
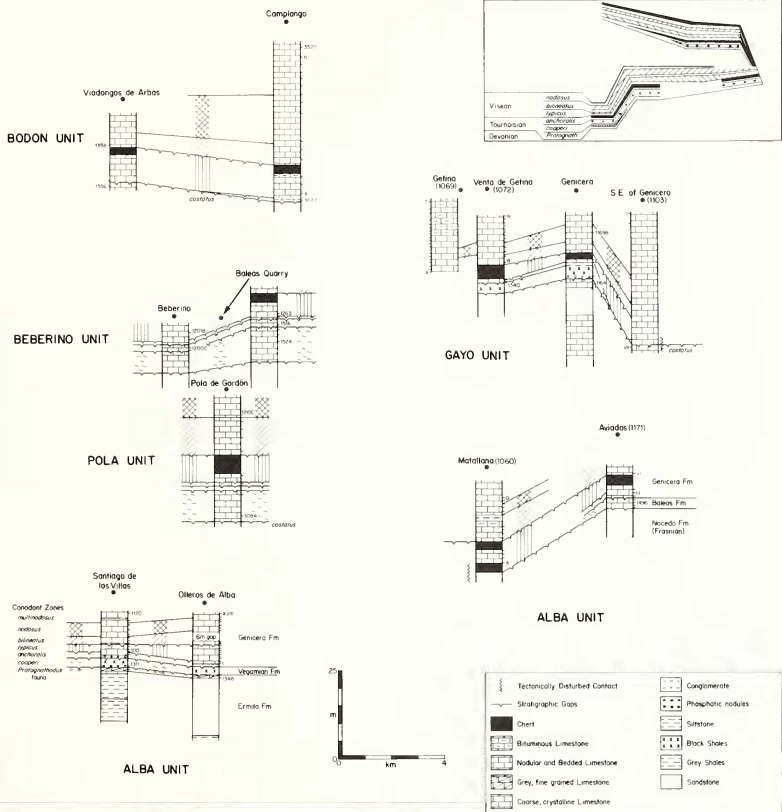
TEXT-FIG. 8. Geographical location and conodont sequences of the sections on the Porma-Bernesga area. The units are structural ones, usually isoclinal synclines separated by thrusts. The inset ribbon diagram illustrates the distribution of the zones.

(griotte). The fauna commonly occurs in a fine grained non-nodular limestone and is of the 'swell' type being composed of gnathodids together with some locally abundant polygnathids and pseudopolygnathids. However, there are no swells identifiable in this zone, merely a general shallowing over the whole region except in the extreme east where the Vegamián Formation persists. In the south-east, the Revilla Nappe, the Vegamián Formation is absent and the oldest Carboniferous is a thin sandy limestone of *anchoralis* age representing the southerly extension of the Lower Carboniferous sea.

Visean history. As already stated, it is believed that the *anchoralis* Zone is incomplete, only the lower part being present. There is, however, no obvious physical expression of this break in the rock successions except the occasional absence of the *anchoralis* faunas as at Viadangos de Arbas and possibly at Gildar-Montó where Budinger and Kullmann (1964) date the base of the Carboniferous as late Visean.

The Visean begins with the *typicus* Zone, less than 5 m thick, and with a much-reduced conodont abundance of nineteen specimens per kilogram compared to ninety-seven per kilogram in the *anchoralis* Zone, indicating more rapid deposition. At the top of the zone the nodular limestones give way to horizons and nodules of radiolarian cherts in red shales, which are extensively developed in the Porma–Bernesga–Esla area.

Immediately above the chert the fauna changes markedly with the incoming of *Gnathodus bilineatus* and the change reflects the absence of at least one fauna. In comparison with Belgium and Ireland *Paragnathodus commutatus* appears later in Spain, both in the Cantabrian Mountains and in the Pyrenees (Marks and Wensink 1970), by at least one zone. Also absent is the *G. bulbosus* fauna of mid-Osage age (Thompson and Fellows 1970). It is possible that these zones are represented by the chert horizon but in chert-free sections the faunal break is still present. This non-sequence is clearly of more than local significance.

Above the chert the sequence appears to be unbroken, although still condensed, and both the goniatite and the conodont records are complete.

SYSTEMATIC PALAEONTOLOGY

(A. C. Higgins)

CONODONTS

Where specimens can be related to natural assemblages they are referred to multi-element species such as *Gnathodus bilineatus* and *Idioprioniodus conjunctus*. Where this is not possible specimens are referred to disjunct species. The non-platform elements in the Spanish sections are too disproportionately represented, either due to breakage or selective sorting, to allow the construction of multi-element species by means of similarity of ratios and ranges.

Type and figured specimens are housed in the micropalaeontology collection, Department of Geology, University of Sheffield.

Multi-element species

Genus GNATHODUS Pander, 1856

Type species. Gnathodus mosquensis Pander 1856.

Gnathodus bilineatus bilineatus (Roundy) 1926

1926   *Polygnathus bilineata* Roundy, p. 13, pl. 3, fig. 10*a–c*.
1964   *Gnathodus bilineatus* (Roundy), Schmidt and Müller 1964, p. 114, figs. 7, 8.

P element

Plate 34, figs. 1, 3

For a recent synonymy see Higgins 1975, p. 28.

Remarks. In the *Gnathodus bilineatus* Zone two morphotypes of this species occur. One is the typical form of *G. bilineatus* with an inner platform consisting of a transversely ribbed ridge extending to the posterior end of the platform whereas the other has a short inner platform which does not extend to the posterior end. The latter morphotype was referred to *G. delicatus* by Adrichem Boogaert (1967) and to *G. bilineatus* subsp. nov. by Higgins (1974). Although it bears some similarities to *G. delicatus* it would considerably extend the range of that species, and its occurrence is separated from that species by a stratigraphic gap. It is probably better regarded as a variant of *G. bilineatus* rather than a relative of *G. delicatus.*

O Element

Plate 34, fig. 19

1932   *Bryantodus delicatus* Stauffer and Plummer, p. 29, pl. 2, fig. 27.
1941   *Ozarkodina delicatula* (Stauffer and Plummer), Ellison, p. 120, pl. 20, figs. 40–42, 47.

For a recent synonymy see Higgins 1975, p. 69.

Remarks. The denticles of the O element and the other non-platform elements of *Gnathodus bilineatus* are ornamented with marked striations similar to those of the Oz element of *Idiognathodus delicatus* illustrated by von Bitter (1972). They consist of striations, 1 to 2 microns thick, rounded and sometimes continuous but sinuous and in other instances thickening and thinning down the length of the denticle. This pattern has been described by Norby (1975).

N Element

Plate 34, fig. 25

1933   *Synprioniodina* sp. Gunnell, p. 296, pl. 31, fig. 6.
1941   *Synprioniodina microdenta* Ellison, pp. 108–111, 119, pl. 120, figs. 43–46.

For a recent synonymy see Higgins 1975, pp. 38, 39.

A_{1a+b} Elements

Plate 34, figs. 20, 22

1957   *Hindeodella ibergensis* Bischoff, p. 28, pl. 8, figs. 33, 37, 39.

For a recent synonymy see Higgins 1975, pp. 38, 39.

Remarks. Baesemann (1973) provided a complete description of these two elements. The A_{1a} element, typically with forwardly inclined denticles on the anterior process is illustrated extensively by Higgins (1975, p. 39, fig. 8*a, c, d, f*). The A_{1b} element, with strongly inwardly flexed denticles on the anterior process is illustrated by Higgins (1975, p. 39, fig. 8*b, e*).

A_{1c} Element

1959   *Hindeodina uncata* Hass, p. 383, pl. 47, fig. 6.

A recent synonymy is given in Higgins (1975, p. 44).

Remarks. Although this element was not included by Baesemann (1973) or von Bitter (1972) in *Idiognathodus delicatus* it is commonly present in Lower and Upper Carboniferous faunas in association with gnathodid and idiognathodid elements and it was recorded from such assemblages by Schmidt and Müller (1964, p. 117, fig. 9 (6)).

A_2 Element

Plate 34, fig. 24

1957   *Angulodus walrathi* Bischoff, p. 17, pl. 5, figs. 44, 45.
1975   *Hindeodella simplex* (Higgins and Bouckaert), Higgins 1975, pl. 5, figs. 10, 12, 13.

A recent synonymy is given in Higgins 1975, pl. 42.

Remarks. A complete description is given in Higgins and Bouckaert (1968, pp. 28, 29) and Baesemann (1973, p. 704).

A_3 Element

Plate 34, fig. 26

1965   *Hibbardella acuta* Murray and Chronic, p. 598, pl. 73, figs. 3–5.

A recent synonymy is given in Higgins 1975, p. 34.

EXPLANATION OF PLATE 34
All specimens × 40

Gnathodus bilineatus bilineatus (Roundy)

Figs. 1, 3. P Element, Villabellaco Section, sample 2902, oral views of 2902 (1 and 2).
Fig. 19. O Element, Olleros de Alba Section, sample OLI, inner lateral views of OLI (1).
Fig. 20. A_{1b} Element, Entrago Section, sample 1149C, inner lateral view of 1149C (1).
Fig. 22. A_{1a} Element, Entrago Section, sample 1149K, inner lateral view of 1149K (1).
Fig. 24. A_2 Element, Matallana Section, sample 1060A, inner lateral view of 1060A (1).
Fig. 25. N Element, Entrago Section, sample 1149C, inner lateral view of 1149C (2).
Fig. 26. A_3 Element, Entrago Section, sample 1149K, inner lateral view of 1149K (2).
Fig. 2. *Gnathodus delicatus* Branson and Mehl, Pola de Gordón Section, sample 3085, oral view of 3085 (1).
Figs. 4, 14. *Gnathodus cuneiformis* Mehl and Thomas. 4, Baleas Quarry, Sample 1264, oral view of 1264 (18). 14, Olleros de Alba Section, sample OLV, oral view of OLV (1).
Fig. 5. *Gnathodus typicus* Cooper. Olleros de Alba Section, sample OLIV, oral view of OLIV (1).
Fig. 6. *Gnathodus semiglaber* Bischoff. Baleas Quarry, sample 1264, oral view of 1264 (19).
Fig. 7. *Gnathodus homopunctatus* Bischoff. Revilla Section, sample 134V oral view of 134V (1).
Fig. 8. *Protognathodus collinsoni* Ziegler. Santiago de las Villas Section, sample 1310, oral view of 1310 (1).
Fig. 9. *Gnathodus girtyi girtyi* Hass. Revilla Section, sample 134IX, oral view of 134X (1).
Fig. 10. *Protognathodus meischneri* Ziegler 1969. Santiago de las Villas Section, sample 1310, oral view of 1310.
Fig. 11. *Gnathodus texanus pseudosemiglaber* Thompson and Fellows 1970, Matallana Section, sample 1060A, oral view of 1060A (2).
Figs. 12, 13, 15. *Paragnathodus multinodosus* (Wirth). Revilla Section, sample 134IX, oral view of 134IX (2–4).
Figs. 16, 17. *Mestognathus beckmanni* Bischoff. Villabellaco Section, sample 2910, oral and aboral views of 2910 (1).

Idioprioniodus conjunctus (Gunnell)

Fig. 18. B_{3a} Element, Entrago Section, sample 1149K, posterior view of 1149K (3).
Fig. 21. N_1 Element, Olleros de Alba Section, sample OLI, outer lateral view of OLI (2).
Fig. 23. B_{1b} Element, Entrago Section, sample 1149C, inner lateral view of 1149C (3).
Fig. 27. N_2 Element, Matallana Section, sample 1060A, outer lateral view of 1060A (3).
Fig. 28. B_{1a} Element, Matallana Section, sample 1060A, inner lateral view of 1060A (4).
Fig. 29. B_{3b} Element, Matallana Section, sample 1060A, outer lateral view of 1060A (5).
Fig. 30. *Scaliognathus* sp. nov. Olleros de Alba section, sample 1340, oral view of specimen 1340 (1), × 60.
Fig. 31. *Scaliognathus* sp. nov. Olleros de Alba section, sample OLI, oral view of specimen OLI (5), × 60.
Fig. 32. *Scaliognathus* sp. nov. Olleros de Alba section, sample OLI, oral view of specimen OLI (4), × 60.

PLATE 34
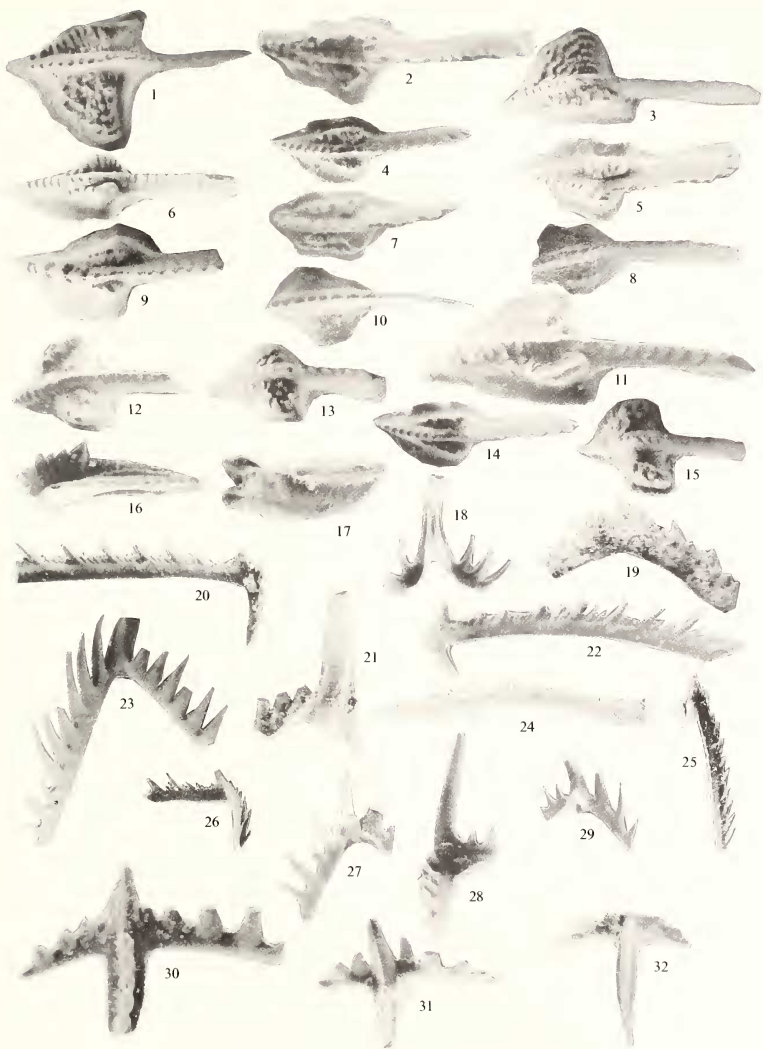
HIGGINS and WAGNER-GENTIS, Earlier Carboniferous conodonts

Genus IDIOPRIONIODUS Gunnell 1933

1933   *Idioprioniodus* Gunnell, p. 265.
1952   *Duboisella* Rhodes, p. 895.
1972   *Neoprioniodus* Rhodes and Müller, von Bitter, p. 68.
1973   *Idioprioniodus* Gunnell, Baesemann, p. 703.
1974   *Idioprioniodus* Gunnell, Merrill and Merrill, pp. 119–130.

Type species. Idioprioniodus typus Gunnell, 1933.

Idioprioniodus conjunctus (Gunnell) 1931

1931   *Prioniodus conjunctus* Gunnell, p. 247, pl. 29, fig. 7.
1974   *Idioprioniodus conjunctus* (Gunnell), Merrill and Merrill, p. 120.

Remarks. Merrill and Merrill (1974) proposed this species for pre-Missourian representatives of *Idioprioniodus* which would be assigned to *Idioprioniodus typus* (Gunnell) except for the presence of an N_2 (metalonchodinid) element.

N_1 Element

Plate 34, fig. 21

1931   *Prioniodus conjunctus* Gunnell, p. 247, pl. 29, fig. 7.

A complete synonymy is given in Higgins 1975, p. 66.

N_2 Element

Plate 34, fig. 27

1931   *Prioniodus bidentatus* Gunnell, p. 247, pl. 29, fig. 6.
1941   *Metalonchodina bidentata* (Gunnell), Branson and Mehl, p. 106, pl. 19, fig. 34.

A complete synonymy is given in Higgins 1975, p. 63.

B_{1a} Element

Plate 34, fig. 28

1933   *Idioprioniodus typus* Gunnell, p. 265, pl. 31, fig. 47.
1941   *Ligonodina typa* (Gunnell), Ellison, p. 114, pl. 20, figs. 8–11.
1953   *Ligonodina roundyi* Hass, p. 82, pl. 15, figs. 5–9.
1972   *Neoprioniodus conjunctus* (Gunnell), Von Bitter, p. 69, pl. 12, fig. 3, Hi element.
1973   *Idioprioniodus lexingtonensis* (Gunnell), Baesemann, p. 703, pl. 3, fig. 1.

Remarks. Higgins (1975) regarded *Ligonodina roundyi* and *L. typa* as separate species because the former species has discrete anterior process denticles. However, both species have the same range and there are transitional specimens throughout this range.

B_{1b} Element

Plate 34, fig. 23

1931   *Prioniodus clarki* Gunnell, p. 247, pl. 29, fig. 8.
1941   *Lonchodina clarki* (Gunnell), Ellison, p. 116, pl. 20, figs. 21, 27, 30, 31.
1957   *Lonchodina* cf. *projecta* Ulrich and Bassler, Bischoff, p. 34, pl. 1, fig. 20.
1961   *Lonchodina* cf. *projecta* Ulrich and Bassler, Higgins, pl. 11, fig. 10.
1968   *Lonchodina bischoffi* Higgins and Bouckaert, p. 43.
1972   *Neoprioniodus conjunctus* (Gunnell), Von Bitter, p. 69, pl. 12, fig. 4a–c, Pl. element.

1973   *Idioprioniodus lexingtonensis* (Gunnell), Baesemann, p. 704, pl. 3, fig. 2, B_{1b} element.
1975   *Lonchodina bischoffi* Higgins and Bouckaert, Higgins, p. 59, pl. 2, figs. 1–4, 8.

For a complete description see Higgins and Bouckaert (1968), p. 43.

Remarks. None of the illustrated specimens of *Lonchodina clarki* from the Pennsylvanian are as complete as the specimens assigned to *L. bischoffi* which have been described from the Visean and Namurian. Both the anterior process and the posterior process of the former species are incomplete. None the less, in all other respects the two species are identical and there seems little justification in retaining them as separate species.

B_2 Element

1931   *Prioniodus lexingtonensis* Gunnell, p. 246, pl. 29, fig. 4.
1941   *Ligonodina lexingtonensis* (Gunnell), Ellison, p. 115, pl. 20, figs. 13–15.
1973   *Idioprioniodus lexingtonensis* (Gunnell), Baesemann, p. 704, pl. 3, figs. 3, 8.

For a more complete synonymy and a description see Higgins (1975), p. 58.

B_{3a} Element

Plate 34, fig. 18

1931   *Prioniodus subacodus* Gunnell, p. 246, pl. 29, fig. 5.
1941   *Hibbardella subacoda* (Gunnell), Ellison, p. 118, pl. 20, figs. 22, 26.
1953   *Roundya barnettana* Hass, p. 89, pl. 16, figs. 8, 9.
1958   *Roundya costata* Rexroad, p. 26, pl. 2, figs. 5–8.
1972   *Neoprioniodus conjunctus* (Gunnell), Von Bitter, p. 70, pl. 16, figs. 2a, b, Tr element.
1973   *Idioprioniodus lexingtonensis* (Gunnell), Baesemann, p. 704, pl. 3, fig. 9, B_{3a} element.

Remarks. Specimens from the Missourian illustrated by Baesemann (1973) and the late Pennsylvanian illustrated by Von Bitter (1972) and referred to *Roundya subacoda* are indistinguishable from early Carboniferous specimens of *R. barnettana*. The distinction between the two species is the massivity of the unit of *R. subacoda* compared to *R. barnettana*. Comparison between them is made difficult by the incomplete nature of the later Pennsylvanian specimens but the distinction would seem to be of superficial importance.

B_{3b} Element

Plate 34, fig. 29

1941   *Lonchodina ?ponderosa* Ellison, p. 116, pl. 20, figs. 37–39.
1958   *Lonchodina paraclaviger* Rexroad, p. 22, pl. 4, figs. 7–10.
1973   *Idioprioniodus lexingtonensis* (Gunnell), Baesemann, p. 704, pl. 3, figs. 4, 5, B_{3b} element.
1975   *Lonchodina paraclaviger* Rexroad, Higgins, p. 60, pl. 2, fig. 9.

Remarks. The similarity between *Lonchodina ponderosa* and *L. paraclaviger* is illustrated by Higgins 1975, pl. 2, figs. 9, 11. Both species have processes almost in the same plane, subequal denticles on the anterior process which are approximately equal in size to the cusp, and a similar basal cavity. The subsymmetrical nature of the unit suggests that this is a B_3 element as suggested by Baesemann rather than a B_2 element.

Disjunct elements

Genus DOLIOGNATHUS Branson and Mehl, 1941

Type species. Doliognathus latus Branson and Mehl, 1941.

Doliognathus latus Branson and Mehl, 1941

For synonymy up to 1967, see Thompson (1967).

1970   *Doliognathus latus* Branson and Mehl, Thompson and Fellows, p. 45.
1971   *Doliognathus latus* Branson and Mehl, Higgins, pl. 2, figs. 1, 3–6, 8.
1971   *Doliognathus* cf. *latus* Branson and Mehl, Higgins, pl. 2, figs. 2, 7.

Remarks. The considerable variation in this species was illustrated by Voges (1959, p. 274) and Higgins (1971, pl. 2). The typical form, illustrated by fig. 1 of pl. 2 (Higgins 1971) has a transversely ribbed or noded platform, smoothly curved margins, and the outer lateral process is approximately at right angles to the main axis of the unit. The main variant (pl. 2, figs. 2 and 7) has more pronounced platform ribs, strongly irregular platform margins, and the outer lateral process is more strongly curved or directed posteriorly. This latter form was referred to *Doliognathus* cf. *latus* by Higgins (1971).

Genus GNATHODUS Pander, 1956

Type species. Gnathodus mosquensis Pander, 1956.

Gnathodus cuneiformis Mehl and Thomas

Plate 34, figs. 4, 14

1947   *Gnathodus cuneiformis* Mehl and Thomas, p. 10, pl. 1, fig. 2.
1971   *Gnathodus* cf. *girtyi* Hass, Higgins, pl. 5, fig. 3.

A more complete synonymy is given in Thompson and Fellows 1970, pp. 45, 46.

Remarks. Thompson and Fellows (1970) pointed out that *Gnathodus cuneiformis* is homeomorphic with *G. girtyi* in the United States where the former species occurs in the Osagean and the latter in the Chesterian Stage. The same pattern can be observed in Spain where *G. cuneiformis* occurs in the *anchoralis* zone of late Tournaisian age and *G. girtyi* occurs in the *bilineatus* Zone of late Visean age. The range of variation of *G. girtyi* is much greater than that of *G. cuneiformis* but symmetrically platformed specimens of both species are indistinguishable.

Gnathodus delicatus Branson and Mehl

Plate 34, fig. 2

1938   *Gnathodus delicatus* Branson and Mehl, p. 145, pl. 34, figs. 25–27.
1971   *Gnathodus delicatus* Branson and Mehl, Higgins, pl. 5, figs. 5, 7, 8, 11, 13.

Recent synonymies have been given by Butler (1973, p. 497) and Matthews *et al.* (1972, p. 559).

Remarks. Butler (1973) commented that specimens from the upper part of the range of this species show the development of a distinct parapet at the anterior end of the inner side of the platform. This form (pl. 5, figs. 5, 7 of Higgins 1971) also occurs in the Spanish sections where it overlaps the range of *Gnathodus antetexanus*, a species which, as pointed out by Butler, has a similar feature.

Gnathodus girtyi girtyi Hass, 1953

Plate 34, fig. 9

1953   *Gnathodus girtyi* Hass, p. 80, pl. 14, figs. 22–24.
1975   *Gnathodus girtyi girtyi* Hass, Higgins, p. 31, pl. 10, figs. 5, 6.

A more complete synonymy is given in Higgins (1975), p. 31.

Remarks. Only the weakly ornamented subspecies of *Gnathodus girtyi* is represented in the Spanish succession and it is a rare species.

Gnathodus typicus Cooper, 1939

Plate 34, fig. 5

1939 *Gnathodus typicus* Cooper, p. 388, pl. 42, figs. 77, 78.
1964 *Gnathodus typicus* Cooper, Rexroad and Scott, p. 31, pl. 2, fig. 3.
1970 *Gnathodus typicus* Cooper, Thompson and Fellows, pp. 89, 90, pl. 3, figs. 3, 13.

Remarks. Specimens with a short anteriorly pointing inner platform and a weakly ornamented outer, wide, and rounded platform are referred to this species. Expansion of the carina would allow it to be placed in *Gnathodus semiglaber* with which species it has much in common.

Genus PARAGNATHODUS Higgins, 1975

Type species. Spathognathodus commutatus Branson and Mehl, 1941.

Remarks. Paragnathodus commutatus and *P. nodosus* (Bischoff) 1957, have recently been described by Higgins 1975, pp. 70–72. The composition of the multi-element genus is unknown but it is likely to correspond to the natural assemblage *Lochreia* of Scott 1942.

Paragnathodus multinodosus (Wirth), 1967

Plate 34, figs. 12, 13, 15; text-fig. 10*b*

1962 *Gnathodus commutatus* var. *multinodosus* Higgins, pp. 8, 9, pl. 2, figs. 13–18.
1967 *Gnathodus commutatus multinodosus* n.ssp. Wirth, p. 208, pl. 19, figs. 19, 20.
1974 *Gnathodus commutatus multinodosus* Higgins, Austin and Husri, pl. 2, fig. 13.

Discussion. Variation in this species is mainly seen in the shape of the cup and its ornamentation. The cup shape can vary from being subsymmetrical to asymmetrical where the inner side is strongly folded both anteriorly and posteriorly and does not gradually taper to the posterior. The nodes typically evenly cover the platform surface where they are situated on a slightly raised shelf. Pl. 34, fig. 12, illustrates a specimen in which the nodes are raised on two anteriorly directed ridges identical to those found in *Paragnathodus nodosus* and it may be a variant of this species. Scanning photographs reveal the presence of micronodes on the major nodes of *P. multinodosus* (Pl. 35, fig. 2).

Remarks. The distribution of this species is very restricted. Apart from its widespread presence in the Cantabrian Mountains it occurs in the Pyrenees (Wirth 1967; Marks and Wensink 1970; Perret 1974) and possibly in Ireland (Austin and Husri 1974) but is unknown elsewhere despite the large numbers of faunas of this age which have been described. The Irish occurrence is abnormal because it apparently occurs before *P. nodosus*, whereas in Spain it appears slightly later.

Genus SCALIOGNATHUS Branson and Mehl, 1941

Type species. Scaliognathus anchoralis Branson and Mehl, 1941.

Discussion. Despite the widespread nature and stratigraphical importance of this distinctive anchor-shaped genus it remains monospecific. The Spanish successions, being condensed and broken by non-sequences, do not give a clear pattern of evolution of the genus. Nevertheless, the material is well preserved and abundant, and it is possible to identify the main variations in the genus. Three main forms are recognized:

1. Forms with plate-like lateral and anterior processes. These are referred to *Scaliognathus anchoralis*.
2. Forms with a plate-like anterior process, but blade-like subequal lateral processes which are curved anteriorly. These are referred to *S. angustilateralis* sp. nov.
3. Forms with straight unequal lateral limbs which project at right angles to the anterior process. The posterior limbs are blade-like. These are referred to *Scaliognathus* sp. nov.

Groessens (1977a) suggested an origin for *Scaliognathus* from *Dollymae bouckaerti* (Groessens) in which the first scaliognathid was a slender, highly arched form with poor plate development. This form would resemble form 2 above.

Scaliognathus anchoralis Branson and Mehl, 1941

Text-fig. 9a, b, d, g

1941   *Scaliognathus anchoralis* Branson and Mehl, p. 102, pl. 19, figs. 29–32.
1964   *Scaliognathus anchoralis* Branson and Mehl, Higgins *et al.* pl. iv, fig. 17.
1967   *Scaliognathus anchoralis* Branson and Mehl, Adrichem Boogaert, p. 50, pl. 5, figs. 2–4, 8, 9.
1969a   *Scaliognathus anchoralis* Branson and Mehl, Matthews, pp. 272, 273, pl. 49, figs. 2, 4, 8, and 9 only.
1969b   *Scaliognathus anchoralis* Branson and Mehl, Matthews, pl. 51, figs. 1, 2.
1971   *Scaliognathus anchoralis* Branson and Mehl, Groessens, pl. 1, fig. 10 only.
1971   *Scaliognathus anchoralis* Branson and Mehl, Higgins, pl. 3, figs. 3, 5–7, 9; pl. 4, fig. 2.
1974   *Scaliognathus anchoralis* Branson and Mehl, Matthews and Thomas, pl. 50, figs. 8, 9.
1974   *Scaliognathus anchoralis* Branson and Mehl, Jenkins, pl. 119, figs. 6–9.
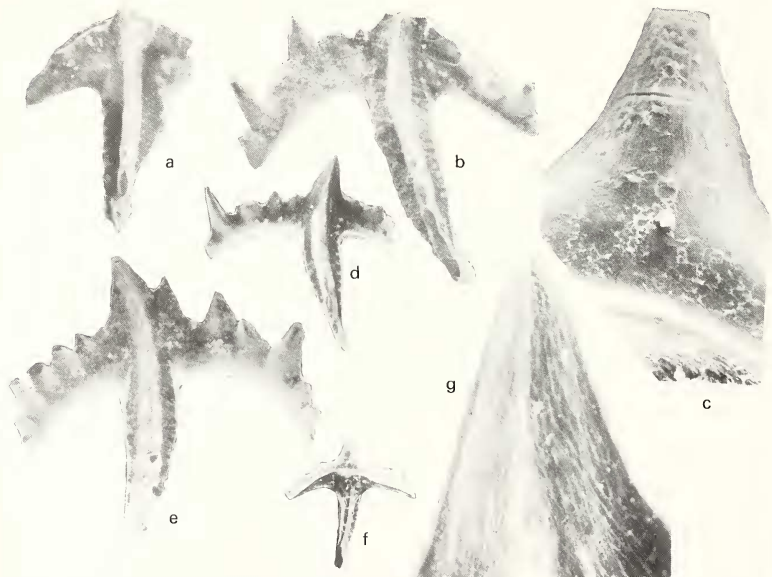
TEXT-FIG. 9. *a, Scaliognathus anchoralis* Branson and Mehl. Olleros de Alba section, sample 1340, oral view of specimen 1340 (2), × 60. *b, Scaliognathus anchoralis* Branson and Mehl. Baleas Quarry, sample 1264, oral view of specimen 1264 (23), × 60. *c, f, Scaliognathus angustilateralis* sp. nov. Baleas Quarry, sample 1264; fig. *c* aboral view of cusp, × 1080; fig. *f* aboral view of specimen 1264 (20), × 60. *d, g, Scaliognathus anchoralis* Branson and Mehl. Olleros de Alba section, sample OLI; fig. 5 oral view of specimen OLI (3), × 60; fig. *g* detail of main denticle, × 360. *e, Scaliognathus angustilateralis* sp. nov. Baleas Quarry, sample 1264, oral view of holotype, specimen 1264 (22), × 60.

Diagnosis. Paired conodonts with an anchor-like shape consisting of three processes. The anterior process is wide, tapering to its anterior extremity, the two posterior lateral processes are also wide and plate-like with a row of posteriorly inclined denticles on a flat and horizontal upper surface, which is in the same plane as the surface of the lateral process.

Description. The anterior limb is broad at the posterior tapering anteriorly with a convex outer and a convex, straight or slightly concave, inner margin. There is a prominent median carina consisting of large discrete denticles at the anterior becoming fused into a low ridge towards the posterior. At the posterior the carina is continued beyond the extremity of the platform as a horn-like denticle which is commonly large and may have a triangular cross-section where the carinal ridge continues up its oral face, but there is no sign of this in the holotype which has a small posterior denticle. There is commonly a sulcus on either side of the carina and bordering the sulci is a row of nodes which may develop into transverse ridges. The lateral extension of the anterior limb is marked, giving rise to a plate-like structure with sharp margins and a flat to concave upper surface.

The lateral processes are as long or slightly shorter than the anterior limb either in length, denticulation, or curvatures. They are projected or curved anteriorly at approximately 70° to the anterior limb and, if curved, curvature is stronger on the outer limb. They are as wide or wider than the anterior limb in the median area of the unit but taper to a point. The oral surface is flat and in the same plane as the oral surface of the anterior limb with which it is continuous. There is commonly a row of low nodes along its anterior margin. Near, or at the posterior margin, is a row of posteriorly inclined denticles which may be subequal in size or increase slightly in height towards the extremity of the limbs. The holotype and paratype have a prominent shelf, with a row of the transverse ridges posterior to the denticle row, but this is atypical for the species in general and more commonly the shelf, although often present, is insignificant. The denticles may be discrete, but are more commonly in contact in the lower third of their length.

The aboral surface of both the anterior and the lateral limbs is convex and smooth except for prominent split keels which are grooved along their length. The keels meet at the centre of the lateral limbs and a triangular open pit which is open in small specimens but becomes more closed in adult specimens. The anterior face of the lateral process is almost at right angles to the oral face, whereas the posterior face is at an angle of approximately 45 degrees.

Discussion. The holotype of Branson and Mehl (1941, pl. 19, figs. 30, 32) has very broad plate-like lateral processes and a denticular row which originates near the midline of these processes. The specimen figured by Jenkins (1974, pl. 119, fig. 6) is close to the holotype but few others, mainly from Europe, are exactly of this type. The description and diagnosis given above retains the plate-like nature of the processes but the typical specimen has a denticular row originating from the posterior edge of the processes which typifies the majority of figured specimens. This redefinition of the species would include form 1 and possibly form 2 of Matthews (1969*a*).

Range. Scaliognathus anchoralis Zone.

No. of specimens fifty.

<div align="center">

Scaliognathus angustilateralis sp. nov.

Text-fig. 9*c, e, f*

</div>

1967   *Scaliognathus anchoralis* Branson and Mehl, Adrichem Boogaert, p. 185, pl. 3, fig. 11.
1969   *Scaliognathus anchoralis* Branson and Mehl, Matthews, pp. 272, 273, pl. 49, figs. 1, 6 only.
1971   *Scaliognathus anchoralis* Branson and Mehl, Groessens, pl. 1, fig. 9 only.
1971   *Scaliognathus anchoralis* Branson and Mehl, Higgins, pl. 3, figs. 1, 2, 4, 8, 10 only.
1973   *Scaliognathus anchoralis* Branson and Mehl, Butler, p. 510, pl. 58, figs. 6 and 7 only.

Derivation of name. Refers to the narrowness of the lateral process.

Holotype. Text-fig. 9*d*, from the Baleas Formation, Baleas Quarry, Pola de Gordón. Slide 1264(22).

Diagnosis. A species of *Scaliognathus* with narrow lateral processes which are posteriorly inclined, curved anteriorly, and in the same plane as the row of denticles which are developed on its surface.

Description. The anterior limb is slender, plate-like, with a convex outer and convex to concave inner margin which are approximately parallel in the posterior half but taper sharply in the anterior half usually terminating before the end of the process. The oral surface of the limb is bisected by a median carina consisting of partially fused, large denticles in the anterior half which becomes a fused, low, nodular ridge in the posterior half extending up the oral face of the horn-like terminal denticle. The margins of the limb are slightly crenulate because of the development of a row of nodes and transverse ridges on each side. These are separated from the carina by a shallow sulcus.

The lateral limbs are subequal and are curved anteriorly, often strongly, and in extreme variants the anterior half of the outer limb may be parallel to the anterior limb. There is no development of a plate on the limbs and they consist of narrow, strongly posteriorly inclined and often curved, blade-like processes. There may be a row of small nodes along the anterior margin or the oral face may be smooth. The denticles originate from the posterior margin and are in the same plane as the processes. They are long, discrete for more than half their length, and laterally compressed.

The aboral side is convex and has a raised split keel which meets in a triangular pit.

The oral surface of the platform adjacent to the main denticle and the carina is covered by an irregular to hexagonal pattern of furrows. These cross and interrupt a pattern of branching fine striae. The oral surface of the main denticle also has a pattern of coarse striations but raised rather than sunken and always semiregular. These run approximately parallel to the margin of the denticle and meet at the ridge which bisects it. There are no fine striae on the oral surface. The aboral surface has an irregular pattern of coarse striations, again ridges, overlying a finer one, but in this instance the finer one may branch off the coarser ones. These patterns are also found in *Scaliognathus anchoralis* and *Scaliognathus* sp. nov.

Range. Lower part of the *anchoralis* Zone.

No. of specimens sixty.

Scaliognathus sp. nov.

Plate 34, figs. 30–32; text-fig. 10*a*

1969   *Scaliognathus anchoralis* Branson and Mehl, Matthews, pp. 272, 273, pl. 49, figs. 5 and 7 only.

Description. Anterior limb is slender and strongly arched with convex margins to a weakly developed plate. The oral surface of the plate is unornamented and smooth except for the median row of discrete pointed denticles which are inclined posteriorly.

The lateral limbs are unequal, the outer being up to twice the length of the inner. Both limbs are slender, being only slightly thickened adjacent to the junction with the anterior limb. They are steeply inclined, almost vertical, with a slight inclination towards the posterior. Their oral edge is ornamented with discrete, long denticles which are laterally flattened, with up to five on the outer and two or three on the inner side. The denticles are in the same plane as the limbs. The largest denticle is at the end of the carina and is triangular being bisected by a low ridge.

a   b   c
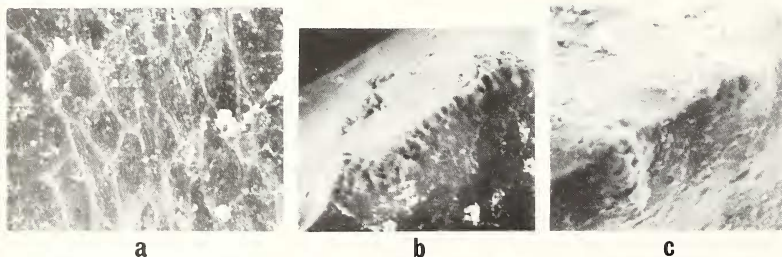
TEXT-FIG. 10. *a, Scaliognathus* sp. nov. Detail of platform area adjacent to main denticle of specimen 1340 (1), × 1080.   *b, Paragnathodus multinodosus* (Wirth). Detail of carinal node of specimen 1341X, × 550.   *c, Protognathodus meischneri* Ziegler 1969. Detail of carinal node of specimen 1310 (2), × 550.

The aboral side of the anterior limb is convex but that of the lateral limb is sharp edged except adjacent to their junction with the anterior limb. All the limbs have split keels which meet in a triangular cavity beneath the base of the triangular denticle.

Range. Upper part of the *anchoralis* Zone.

GONIATITES

(C. H. T. Wagner-Gentis)

Family PROLECANITIDAE Hyatt, 1884
Genus MEROCANITES Schindewolf, 1922

Type species. Ellipsolithes compressus Sowerby, 1813.

Merocanites marshallensis (Winchell)

Plate 35, figs. 1, 2, 6; text-fig. 11a, b

1862   *Goniatites Marshallensis* Winchell, pp. 362, 363.
1955   *Merocanites marshallensis* Winchell, Miller and Garner, pp. 154–157, pl. VII, figs. 5–9, text-figs. 13c and 16.

Material. Two specimens and a large number of whorl-sections from localities 138, 138D, 1548, from the Villabellaco Limestone in Palencia.

Description. The shell is a serpenticone with a rectangular cross-section of the whorl. The venter and ventro-lateral edge are both rounded, the umbilical wall is flat and perpendicular to the lateral side (see text-fig. 11b). Neither ornament nor constrictions have been observed. The suture consists of an inflated ventral lobe of which the siphonal point can be rather long. The ventro-lateral saddle is rounded, constricted, and low. The first lateral lobe is pointed, constricted, and not as deep as the ventral lobe, but it is wider than the ventral or second lateral lobe. The following lateral saddle is rounded, constricted, and higher than the ventro-lateral saddle. The second lateral lobe is pointed, constricted, and longer than the first lateral lobe. The last lateral saddle is rounded, constricted, and smaller than the preceding saddles. The third lateral lobe is pointed, considerably smaller than the previous lateral lobes, and slightly asymmetrical. The suture crosses the umbilical wall in a straight line, sloping downwards. It forms a lobe on the dorsal side, which is followed by a narrow, rounded saddle. The median, dorsal lobe is narrow, long, and rounded (see text-fig. 11a).

The dimensions of one of the shells (loc. 138D) are: diameter 38 mm; width 10 mm; umbilicus 14 mm; height of whorl 15 mm; opening 13 mm.

Remarks. Merocanites marshallensis europaeus Kullmann, 1963, pp. 276–278, from the Esla area and Puente de Alba, province of León, is quite different from *M. marshallensis* (Winchell), in that its whorl cross-section is too circular, its ventral lobe, although inflated, is considerably slimmer, and its third lateral lobe is too developed.

Comparisons. The specimens described here differ from *M. applanatus bicarinatus* Pareyn in that the first lateral lobe is wider; the whorls are slightly more indented and, above all, no remnants are found of any ventro-lateral ridges. One specimen from Olleros de Alba (León), which is identical to *bicarinatus*, shows very clearly the differences mentioned above.

Occurrence. M. marshallensis (Winchell) is known from the Marshall Sandstone in Michigan, U.S.A., where it occurs together with *Winchelloceras allei, Muensteroceras oweni, Kazakhstania karagandaensis, Gattendorfia stunmi,* and *Imitoceras romingeri* which indicate a basal Osagean age (Furnish and Manger 1973, p. 3). In the Villabellaco Limestone (Palencia), it occurs together with *Merocanites subhenslowi, Nautellipsites hispanicus, Ammonellipsites kayseri,* and *Pseudogirtyoceras villabellacoi* at 1·5 to 2·5 m above the base of the limestone, which indicate a lowest Visean age.

Family MUENSTEROCERATIDAE Librovitch, 1957
Genus MUENSTEROCERAS Hyatt, 1883

Type species. Goniatites oweni var. *parallela* Hall, 1860.

Merocanites marshallensis (Winchell)
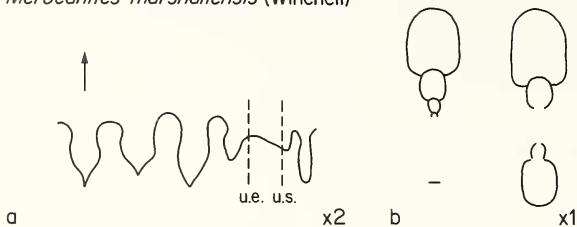
TEXT-FIG. 11. *a*, Suture of specimen BM(NH) C.82316. *b*, Cross-section of same specimen.

Muensteroceras parallelum (Hall)

Plate 35, figs. 4, 5; text-fig. 12

1860   *Goniatites oweni* var. *parallela* Hall, p. 100, figs. 13–14.
1903   *Muensteroceras parallelum* Hall, J. P. Smith, pp. 121, 122, pl. XVI, fig. 3; pl. XIX, figs. 1, 2.
1927   *Muensteroceras* aff. *parallelum* Hall, Librovitch, pp. 32, 33, pl. V, figs. 8, 9; pl. VI, fig. 1.
1951   *Munsteroceras parallelum* Hall, Miller and Collinson, p. 471, fig. 7.
1961   *Munsteroceras parallelum* Hall, Pareyn, pp. 96, 97, pl. VII, figs. 1–3.

Material. One solid specimen from locality 136B from the Villabellaco Limestone (Palencia).

Description. The shell is a very flat, involute platycone, with rounded venter and flat sides. At a diameter of 60 mm the width measures 15 mm. The umbilicus is poorly preserved, but is probably one-sixth of the diameter. The previous whorl, however, at a diameter of 22 mm has a width of 10 mm, which is twice as wide as the last whorl. It also has more rounded lateral sides than those of the last whorl. Neither constrictions nor ornament are preserved. The sutures consist of ventral lobes with parallel sides which touch each other, and thus form two parallel lines on the venter. The ventro-lateral saddles are fairly narrow and rounded; the lateral lobes are V-shaped and their points reach lower than the ventral lobes; they do not, however, touch the preceding ventro-lateral saddles. The lateral lobes are wide and rounded. There is a small, narrow, pointed umbilical lobe on the umbilical edge. The dimensions of the shells are: diameter 60 mm; width 15 mm; umbilicus 10–12 mm; height of whorl 25 mm.

Comparisons. Muensteroceras parallelum is very similar to *M. rotella* de Koninck but the latter appears to differ by having the ventral lobes encasing each other, whereas in *M. parallelum* they only touch each other.

EXPLANATION OF PLATE 35

Fig. 1. *Merocanites marshallensis* (Winchell). BM(NH) C.82315. Lateral view, showing the rather wide ventro-lateral lobe, × 3.
Fig. 2. *Merocanites marshallensis* (Winchell). BM(NH) C.82316. Lateral view, showing shape of shell, × 3.
Fig. 3. *Muensteroceras* cf. *crassum* (Foord). BM(NH) C.82318. Ventro-lateral view, showing sutures, × 3.
Fig. 4. *Muensteroceras parallelum* (Hall). BM(NH) C.82317. Showing lateral and part of ventral sutures, × 1.
Fig. 5. *Muensteroceras parallelum* (Hall). Same specimen as fig. 4. Lateral view, showing the different shapes of the last and penultimate whorl, × 1.
Fig. 6. *Merocanites marshallensis* (Winchell). BM(NH) C.82315. Ventral view, showing inflated ventral lobe, × 1.

PLATE 35
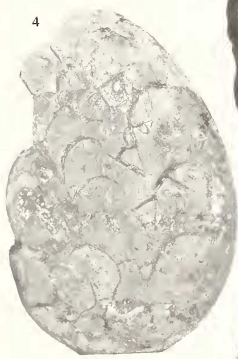
HIGGINS and WAGNER-GENTIS, Earlier Carboniferous goniatites

Occurrence. Villabellaco Limestone, locality 136B, at approximately the same horizon as 138C, but further east in the outcrop. *M. parallelum* was found originally in the Rockford Limestone of Indiana, U.S.A. It is also known from Hassi Sguilma in Algeria, in the S₁ unit of Pareyn 1961, and from the Tien Shan in Central Asia (Librovitch 1927).

Muensteroceras parallelum (Hall)
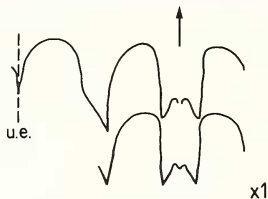
TEXT-FIG. 12. Suture of specimen BM(NH) C.82317.

Muensteroceras cf. *crassum* Foord

Plate 35, fig. 3; text-fig. 13

1903   *Glyphioceras* (*Muensteroceras*) *crassum* Foord, pp. 193–194, pl. XLIII, fig. 10a–c.
1927   *Muensteroceras crassum* Foord; Librovitch, pp. 34–35, pl. VI, fig. 6a–c.
1941   *Muensteroceras crassum* Foord; Delépine, p. 58, pl. II, figs. 4–6.
1961   *Muensteroceras crassum* Foord; Pareyn, pp. 100–101, pl. VIII, figs. 11–16.
1964   *Muensteroceras* cf. *crassum* Foord; Wagner-Gentis in Higgins *et al.*

Material. One solid specimen from the Villabellaco Limestone, found between localities 138B and C.

Description. The shell is an involute ellipsocone. Width about half the diameter. The whorls have a rounded venter and rounded sides, with the greatest width near the umbilicus. The umbilicus is approximately one-quarter of the diameter. Umbilical edges are rounded and the umbilical wall is almost perpendicular and sloping towards the centre of the umbilicus (see text-fig. 13b).
   No ornament has been preserved. There is a faint, shallow impression of a constriction which crosses three-quarters of the sides more or less in a straight line, and then forms a rounded sinus across the venter.
   The suture line consists of a fairly narrow, parallel-sided ventral lobe with a low median saddle. The ventro-lateral saddles are rounded and narrow; the lateral lobes are pointed and as deep as the ventral lobe. The ventral side of the lateral lobe is straight, whereas the umbilical side is curved. The second lateral saddle is low, wide, and rounded. The umbilical lobe is small and pointed, and situated just past the umbilical edge, on the umbilical wall (see text-fig. 13a). The suture lines do not encase each other.

*Dimensions.* Diameter 23 mm; width 12 mm; umbilicus 6 mm; height of whorl 9 mm.

Comparisons. The specimen compares with *Muensteroceras subglobosum* Librovitch, 1927, pp. 35–36, text-fig. 17; pl. VI, fig. 7; pl. VII, figs. 1, 2, in having a similar suture line, but differs in having a larger umbilicus.

Occurrence. Villabellaco Limestone (Palencia) between the localities 138B and C. It has also been described from Olleros de Alba (León). *M. crassum* was first recorded from the Lower Carboniferous Limestone of Ballinacarriga, Co. Limerick, Eire. It is also known from Hassi Sguilma, in Algeria, in the S₁ unit of Pareyn (1961), and from the Tien Shan in Central Asia (Librovitch 1927).

Family PERICYCLIDAE HYATT, 1900
Genus AMMONELLIPSITES Parkinson, 1822

Type species. Ellipsolithes funatus Sowerby, 1814.

Muensteroceras cf. crassum (Foord)
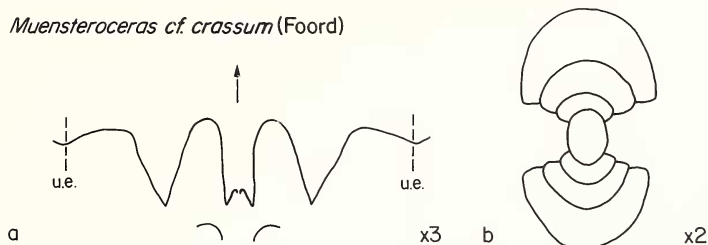
TEXT-FIG. 13. *a*, Suture of specimen BM(NH) C. 82318. *b*, Cross-section of same specimen.

Ammonellipsites kayseri (Schmidt)

Plate 36, figs. 2, 3, 5–7; text-fig. 14*a, b*

1889   *Pericyclus virgatus* Holzapfel, p. 34, Taf. III, figs. 8, 9.
1925   *Pericyclus kayseri* Schmidt, pp. 554, 555, Taf. 20, fig. 10.

Material. Ten specimens from the Villabellaco Limestone (Palencia) and one specimen from Olleros de Alba (León). All show sutures and a number show the ornament fairly clearly or at least traces of the ornament. A plaster cast of Holzapfel's specimen (1889, III, figs. 8, 9) has been used in the description.

Description. The shell is discoidal, involute with a small umbilicus. The venter and the sides are rounded. The early whorls are wider than high, but gradually become higher than wide. The greatest width is half-way down the lateral side of the whorl. The umbilicus, about one-fifth of the diameter, has rounded shoulders and rounded sides, which are perpendicular to the lateral sides (see text-fig. 14*b*).

The ornamentation consists of fairly fine undivided ribs, which lean slightly forward over the sides, and form a very shallow sinus over the venter. The ribs are sharp edged and on the venter the distance between the ribs is more than the width of the rib itself. A specimen with a diameter of about 20 mm has six ribs per 5 mm, on the venter. No constrictions are observed.

The suture consists of a medium saddle, which reaches to one-third of the ventro-lateral saddles. These are slightly spatulate with rounded points and have a tendency to diverge. The rounded points are due to the easy erosion of the sharp point. The lateral lobe is spatulate and pointed. The second lateral saddle is spatulate with a rather blunted point and reaches four-fifths of the height of the first lateral saddle. The umbilical lobe is situated on the umbilical wall and is pointed and wide.

| B.M. (N.H.) numbers | Villabellaco Limestone | | | Plastercast of holotype |
	C82324	C82321	C82322	Holzapfel's specimen
Diameter	20 mm	19 mm	—	38·5 mm
Width	10 mm	11 mm	17 mm	19 mm
Umbilicus	—	4 mm	—	8 mm
Height of whorl	8 mm	8 mm	20 mm	17 mm
Height of opening	—	6 mm	12 mm	12 mm

Comparison. The specimens look very similar to *Pericyclus virgatus* de Koninck, and Holzapfel identified his specimens from Liebstein with this species. Unfortunately, *Pericyclus virgatus* does not show any sutures and it is therefore impossible to decide whether *kayseri* is the same as *virgatus*.

Occurrence. In the Erdbach and Breitscheid cephalopod limestone at Liebstein, Germany (Holzapfel 1889, pp. 34 and 35; Schmidt 1925, p. 494), which according to Schmidt (1925) belongs to the IIγ zone of the Visean, which

Ammonellipsites kayseri (Schmidt)
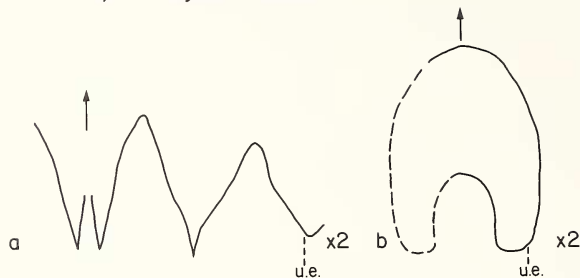
TEXT-FIG. 14. *a*, Suture of specimen BM(NH) C.82322. *b*, Cross-section of specimen BM(NH) C.82322.

is also known as the Pe*γ* of the Erdbachium, the very base of the Visean. From Spain, Schmidt (1931, p. 1035) recorded it together with *P. kochi*, *Imiteroceras* sp., *Merocanites applanatus*, *Muensteroceras* aff. *inconstans*, *M.* cf. *spheroidale*, in Palencia at 1·3 to 2·8 m above the base of the Villabellaco Limestone, and in León at Olleros de Alba. In Great Britain it is mentioned by Prentice and Thomas (1960, p. 6) from Tawstock and Codden Hill where it occurs with *Prolecanites* aff. *similis*.

Family GIRTYOCERATIDAE Wedekind, 1918
Genus WINCHELLOCERAS Ruzhencev, 1965

Type species. Beyrichoceras allei Miller and Garner, 1955.

Winchelloceras palentinus sp. nov.

Plate 36, fig. 1; text-fig. 15*a*–*c*

Type material. One solid specimen preserved in a marly limestone, showing part of the living chamber, sutures, and constrictions.

Repository of holotype. British Museum (Nat. Hist.), No. C82317.

Diagnosis. Shell involute, platyconiform with an umbilicus less than one-sixth of the diameter. Constrictions strongly marked, with a deep, narrowly rounded sinus on the venter, ventro-lateral


PLATE 36

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salient, shallow sinus, and low salient on the lateral sides. Suture with a ventral lobe, of which the spikes are pointed outwards and the cheeks strongly diverging apically. At a diameter of 38 mm the median saddle is still at the very bottom of the ventral lobe. Ventro-lateral saddle rounded, lateral lobe pointed, second lateral saddle wide and rounded. A small V-shaped umbilical lobe is positioned on the umbilical wall.

Description. The shell is a nearly flat, involute platycone. The fairly flat, only slightly rounded, venter is perpendicular to the almost flat lateral sides. The ventro-lateral edge is rounded and there is a suggestion of a groove just below the edge. From there, the lateral side gently curves to become flat near the umbilical region, where the shell has its greatest width. The umbilicus is small, and stepped with rounded edges and narrow walls, which are perpendicular to the sides (see text-fig. 15*b*).

Winchelloceras palentinus nov. sp.
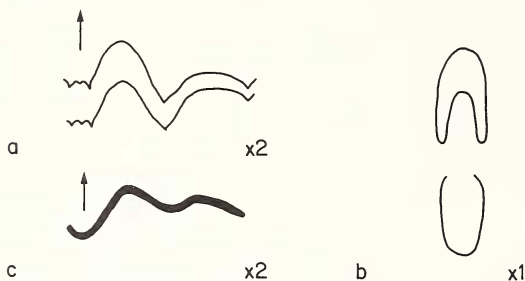
text-fig. 15. *a*, Suture of specimen BM(NH) C.82319. *b*, Cross-section, same specimen. *c*, Constriction, same specimen.

No ornament is preserved. The shell shows four deep, narrow constrictions per whorl. They form a deep, narrowly rounded sinus over the venter and a ventro-lateral salient, which may create the impression of a ventro-lateral groove. On the lateral side the constrictions form a shallow sinus and low salient. They then fade out into the umbilicus (see text-fig. 15*c*).

The sutures have a ventral lobe with an extremely low median saddle, flanked by spikes that are pointing outwards. The cheeks of the ventral lobe are sinuous, first bending outwards and then straightening, in a manner which is opposite to the sinuous cheeks of the ventral lobe in the beyrichoceratids. The ventro-lateral saddles are rounded. The pointed lateral lobes are wide and slightly inflated and the second lateral saddles are wide and rounded, ending in a small V-shaped lobe on the umbilical wall (see text-fig. 15*a*). There are twelve sutures visible on the last whorl, half of the whorl forming the living chamber.

The dimensions of the shell are: diameter 38 mm; width 10 mm; umbilicus 6 mm; height of whorl 19 mm; height of opening 7 mm.

Comparisons. Differs from *Winchelloceras allei* in having a lower median saddle, a flatter venter, and generally a slimmer outline.

Occurrence. Found in the basal 50 cm of the Villabellaco Limestone (Palencia) section. The genus is known from the U.S.A., where it occurs in the Coldwater shale/Marshall sandstone of Michigan, which is of basal Osagean age (Furnish and Manger 1973). It is also recorded from Tien Shan (Popov 1968) and the Urals (Popov 1975) in rocks of C_1v_1 age.

PSEUDOGIRTYOCERAS gen. nov.

Type species. Pseudogirtyoceras villabellacoi sp. nov.